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A Model of Elementary Particle Interactions

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Abstract

There is a second kind of light which does not interact with our electrons. However it interacts with some of our protons (p) and some of our neutrons (n) which are both of two kinds (protons : p, p' , neutrons : n', n) differing in the two kinds of charges (Q_1, Q_2) associated with the two kinds of light. $p[p']$ and $n'[n]$ have (Q_1, Q_2) values equal to (1,1) [(1,0)] and (0,0) [(0,1)] respectively. There is also a second kind of electron ($Q_2 = 1, Q_1 = 0$), equal in mass to our electron ($Q_1 = -1, Q_2 = 0$), , which does not interact with our kind of light. Three major scenarios S_1, S_2 and X_4 arise. In S_1 , matter in the solar system on large scales is predominantly neutralized in both kinds of charges and the weak forces of attraction among the sun and planets are due to a fundamental force of nature. However in this scenario we must postulate that human consciousness is locked on to chemical reactions in the retina involving the first kind of light and the first kind of electrons only. It is oblivious to the simultaneous parallel chemical reactions governed by a chemistry which is based on the second kind of light and the second kind of anti-electrons and involves the same physical atoms manifesting different atomic numbers $Z' (= Q_2)$. In scenario S_2 , matter in the solar system on large scales is predominantly neutralized in the first kind of charge only. In this scenario human consciousness is not restricted in its awareness to a narrowly

Abstract continued.....

circumscribed domain of physical reality. However in this scenario we must accept the existence of very strong forces of attraction in the solar system in order to counteract the strong repulsive forces due to the second kind of charges on the sun and planets. The residual weak force of gravity can not be a fundamental force. In this scenario the problem of unification is more tractable since all the fundamental forces are comparable in strength. Furthermore this scenario allows dark matter to be made up of atoms having nuclei constituted of anti-baryons ($Q_1 < 0, Q_2 < 0$) surrounded by shells of second kind of electrons. The shells of our electrons ($Q_1 < 0, Q_2 = 0$) surrounding our nuclei ($Q_1 > 0, Q_2 > 0$) and the shells of second kind of electrons ($Q_1 = 0, Q_2 > 0$) surrounding the dark matter nuclei ($Q_1 < 0, Q_2 < 0$) help prevent close encounters between the baryons and anti-baryons trapped within their shells of different kinds. [If this scenario holds then dark matter atoms may be harvested for a clean source of energy obtained in collisions with targets composed of our atomic nuclei]. Scenario X_4 envisages the possibility of the two parallel chemistries being identical and producing effects merely reinforcing each other and not causing matter to evolve along competing tracks of chemical evolution. One symmetric version of this scenario allows us to make the following definite prediction: There is a neutron (n') whose mass is equal to that of the proton (p) and a proton (p') whose mass is equal to that of the neutron (n). p' decays with a lifetime equal to the lifetime of the neutron (n). It decays according to

$$\begin{array}{ll} p' \rightarrow p + \overline{e_1} + \overline{\nu^{e_2}} & p' \rightarrow n' + \overline{e_1} + \nu^{e_1} \\ p' \rightarrow p + \overline{e_2} + \overline{\nu^{e_1}} & p' \rightarrow n' + \overline{e_2} + \nu^{e_2} \end{array}$$

Since the uncharged neutrino ν^{e_1} is almost undetectable and the charged anti-neutrino $\overline{\nu^{e_2}}$ events have not been recognized for what they are (viz., the misinterpreted jet events at high energies), the first two of these decays of p' mimic some aspects of the decays of an anti-neutron and have probably been missed being noticed. In this scenario the observed part of the solar neutrino flux, being measured by experiments detecting ν^{e_1} , is expected to be one fourth of the result derived from the standard model (and the solar model) if the modifications introduced by the present model into the solar model itself are ignored. Another version of this scenario has $m(p') = m(p)$ and $m(n') = m(n)$ and is ruled out by experiments. Implications of consequences of the model for the origin of cosmic microwave background, the nature of the Great Attractor, masses of isomers of nuclear isotopes, separation of regions of spin and charge in high T_c superconductors and possible role for non-coding segments in DNA are briefly mentioned. Several other minor scenarios are briefly described. Experiments to decide between the various scenarios are proposed.

1 Questions

We have been trying to make a physical theory that can provide us with answers to the following questions:

1. Why is there an apparent left and right as-symmetry in elementary particle interactions? Is it really present at the presumably fundamental level?
2. Is the appearance of matter and anti-matter as-symmetry real? Is there a more convincing explanation than the so-called Anthropic Principle [1] , whose proponents would probably suggest that the as-symmetry is real since it seems indispensable for local survival of life? Besides, the Anthropic principle is really an antithesis of the Cosmological Principle (or the Copernican Doctrine) in disguise. Could we then avoid invoking contradictory principles to explain different aspects of the cosmos?
3. Can the apparent solar neutrino deficit be explained? Is there a more natural explanation than to assume a mass for the neutrino, in the absence of any direct experimental evidence for it. Would it not be preferable to avoid the element of arbitrariness thereby introduced in the theory?
4. What is the nature of the supernova [2] remnant which was not observed as a supernova, even though it presumably has occurred around 500 AD, a well-documented period of human history?
5. What are the gamma ray bursts? Is there a less contrived explanation than colliding neutron stars [3]?
6. Why is it that the smooth power-law cosmic ray energy spectrum does not fall off abruptly near $5 \cdot 10^{19} \text{eV}$ (the Greisen-Zatsepin-Kuzmin (GZK) threshold [4], [5]), if the cosmic background radiation (CBR) [6] extends all around us? If our estimates of the distances of the potential sources of very high energy cosmic rays, that might have generated cosmic rays with energies above the GZK threshold, are correct then these cosmic rays could not have survived the inelastic interactions with the microwave photons, *if the CBR really exists all the way to these sources of very high energy cosmic rays.*

Is there another explanation, perhaps less radical, than the recently proposed breakdown of Lorentz invariance at very high energies [7]?
7. What is the nature of the CBR? Is there an explanation that does not appeal to an initial singularity? This has been a major outstanding issue since cosmological red-shift was first understood as a natural consequence of a principle more general than special relativity (principle of reciprocity) [8, 9] in a non-expanding flat universe. This effort has (besides prompting investigations of solutions of non-linear problems [10] involving functional iterates of order $\frac{1}{2}$) led to new ideas about the possible fractal-like nature of time measurements [11, 12, 13].
Parenthetical remarks: [A very brief summary of the idea for the proposed explanation of cosmological red-shift given in [8] can be presented here. Consider the situation of the twins, carrying clocks, who are together, get separated from each other for some time and then meet again, all the time moving uniformly along straight lines except when at a certain instant their velocity relative to each other is reversed. It is argued in [8]

that, in spite of the fact that special relativity holds for uniform relative motion, the two clocks initially in agreement also agree when the twins meet again; because each clock as seen by the twin who is not carrying it performs a sudden forward jump in time at the moment of velocity reversal. This forward jump is precisely equal to the time lag (of the other twin's clock) seen by the same twin during the outward and inward uniform motions. Thus inward acceleration is seen to speed up a clock at a rate which increases with acceleration as well as distance of the clock from the observer. In the case of radiating atoms in galaxies the acceleration due to galactic gravitational fields is outward relative to observers on earth. The radiating atoms are therefore seen to produce red-shifted light since the clocks at the location of radiating atoms are being observed to be slowed down due to their outward acceleration in galactic gravitational fields. Application of this argument gives a numerically correct relation between the Hubble constant, the mass and linear size of a typical galaxy, the velocity of light and Newton's constant of gravitation. This effect of acceleration on clocks is quite distinct from the usual gravitational red-shift (in Einstein's theory of gravitation)-the latter is derivable from the minimal form of the equivalence principle without invoking non-Euclidean geometry.

A more precise formulation of this idea, which yields the shapes of *apparent* rotation velocity - central distance profiles for galaxies in agreement with observations, has not yet been submitted for publication because of the strong currents of opposition in the scientific establishment towards works with a potential for promoting unacceptable views about the cosmos. This hostility is manifested, for example, by the systematic obstructions which forced the heroically courageous Halton Arp [14], [15], who persisted in drawing attention to observational evidence for instances of gross non-variation of distance with red-shift (GRINDERS), into reluctant retirement [16].]

The above questions will all be addressed by a new model of electroweak particle interactions which is presented in this paper.

2 The Model

2.1 Symmetries

Apart from the symmetries associated with the Poincaré group of space-time transformations, the model has the symmetries of two gauge groups of rotations in three dimensions; R_1, R_2 and two $U(1)$ gauge groups of phase transformations; U_1, U_2 .

Associated with R_1, R_2 are corresponding (Yang-Mills) gauge fields $W_\mu^{1,j}, W_\mu^{2,j}$, ($j = 1, 2, 3$; $\mu = 0, 1, 2, 3$). Infinitesimal elements in the Poincaré and gauge groups correspondingly generate (inhomogeneous) linear actions with respect to the indices μ and j , respectively. These actions are local. We associate the same dimensionless coupling constant g with $W_\mu^{a,j}$ ($a = 1, 2$).

The generators of infinitesimal transformations in R_1, R_2 are denoted T^j, S^j respectively and satisfy:

$$\begin{aligned} [T^j, T^k] &= i\epsilon^{jkl}T^l \\ [S^j, S^k] &= i\epsilon^{jkl}S^l \\ [T^j, S^k] &= 0 \end{aligned}$$

Associated with U_1, U_2 are corresponding gauge fields B_μ^1 and B_μ^2 . The same dimensionless coupling constant, f , is associated with the B_μ^a s.

The generators of the groups U_1, U_2 are designated U^1, U^2 respectively, and satisfy:

$$\begin{aligned}[U^1, U^2] &= 0 \\ [U^a, T^j] &= 0 \\ [U^a, S^j] &= 0\end{aligned}$$

The generators of the gauge groups commute with the generators of the Poincaré group. There is also a discrete symmetry transformation which is described in sub-section (3.4), page (20).

2.2 Structure of the Model

The model has two kinds of quarks and two kinds of leptons in each family; all are four component Dirac spinors. For example, in the first family we have quarks; u_1, d_1 and u_2, d_2 and leptons; ν^{e_1}, e_1 and ν^{e_2}, e_2 . The description that follows will be presented in terms of the first family, though its content applies analogously to the other families. The leptons in the first family, that are subscripted by 1, have the same quantum numbers as the leptons of the standard model [17, 18, 19, 20].

The model has two kinds of photons

$$\begin{aligned}\mathcal{A}_\mu^a &= \frac{1}{\sqrt{f^2+g^2}}(fW_\mu^{a,3} + gB_\mu^a) \\ a &= 1, 2\end{aligned}\tag{1}$$

and associated charges Q_1 and Q_2 . The assignment of these charges and the baryonic number B for quarks and leptons is given in Table (1).

	Q_1	Q_2	B
u_1	1/3	1/3	-1/3
d_1	-2/3	1/3	-1/3
u_2	2/3	2/3	1/3
d_2	-1/3	2/3	1/3
ν^{e_1}	0	0	0
e_1	-1	0	0
ν^{e_2}	1	1	0
e_2	0	1	0

Table (1)

The spontaneous breakdown of symmetry generated by non-vanishing vacuum expectation values of scalar Higgs fields [21, 22, 23, 24, 25] (details of this aspect of the model will not be presented here) yield four charged massive vector bosons and two neutral massive vector bosons Z_μ^1, Z_μ^2 . The four charged massive vector bosons $W_\mu^{a\pm} = \frac{1}{\sqrt{2}}(W_\mu^{a,1} \pm iW_\mu^{a,2})$ have equal masses M_W , while the two neutral massive vector bosons $Z_\mu^a = \frac{1}{\sqrt{f^2+g^2}}(gW_\mu^{a,3} - fB_\mu^a)$ have equal

masses M_Z . The two kinds of electrons, muons, τ leptons are assumed to have correspondingly equal masses -i.e. $m(e_1) = m(e_2)$. etc. For the two kinds of quarks the corresponding equality of masses $[(m(u_1) = m(u_2), m(d_1) = m(d_2))]$ holds in one of the scenarios considered. Another scenario in which $m(u_1) = m(d_2)$ and $m(u_2) = m(d_1)$ is also considered. The Q_1 and Q_2 charges of the weak interaction bosons are given in Table (2).

	W_μ^{1+}	W_μ^{1-}	W_μ^{2+}	W_μ^{2-}	Z_μ^1	Z_μ^2
Q_1	-1	+1	0	0	0	0
Q_2	0	0	-1	+1	0	0

Table (2)

In what follows, L and R refer to the projections of the Dirac spinors into left and right handed parts, as in the standard model. For a four component Dirac spinor q , we define $\bar{q} = q^\dagger \gamma^0$ and

$$\begin{aligned} q_L &= \frac{1}{2}(1 + \gamma_5)q & q_R &= \frac{1}{2}(1 - \gamma_5)q \\ q'_L &= \gamma^2(q_R)^* & q'_R &= \gamma^2(q_L)^* \end{aligned} \quad (2)$$

The prime ($'$) operation changes the handedness of an object. The reader is referred to the Appendix, for definitions of the γ 's.

Given a bilinear in (anti-commuting) Dirac spinors q, r with c -number coefficients $c_{\alpha\beta}$, we define the operation of anti-symmetrized hermitianization ($A.H.$) as follows:

$$\begin{aligned} A.H. (c_{\alpha\beta} q_\alpha r_\beta) &= \frac{1}{4} [c_{\alpha\beta} q_\alpha r_\beta + \\ &c_{\alpha\beta}^* (r_\beta)^* (q_\alpha)^* - c_{\alpha\beta} r_\beta q_\alpha - c_{\alpha\beta}^* (q_\alpha)^* (r_\beta)^*] \end{aligned} \quad (3)$$

The interactions of the charged vector bosons with the leptons in the family are given by the following terms in the Lagrangian (31):

$$\begin{aligned} A.H. \frac{g}{\sqrt{2}} &\left[(\bar{\nu}^{e_1}_L \quad \bar{e}_{1L}) \gamma^\mu \left\{ \begin{pmatrix} 0 & W_\mu^{1-} \\ W_\mu^{1+} & 0 \end{pmatrix} \right. \right. \\ &\left. \begin{pmatrix} \nu_L^{e_1} \\ e_{1L} \end{pmatrix} + iW_\mu^{2-} \begin{pmatrix} e'_{2L} \\ -\nu'^{e_2}_L \end{pmatrix} \right\} \\ &+ (\bar{\nu}^{e_2}_R \quad \bar{e}_{2R}) \gamma^\mu \left\{ \begin{pmatrix} 0 & W_\mu^{1-} \\ W_\mu^{1+} & 0 \end{pmatrix} \right. \\ &\left. \begin{pmatrix} \nu_R^{e_2} \\ e_{2R} \end{pmatrix} + iW_\mu^{2-} \begin{pmatrix} e'_{1R} \\ -\nu'^{e_1}_R \end{pmatrix} \right\} \Big] \end{aligned} \quad (4)$$

The interactions of the neutral vector bosons with the leptons in the family are given by the terms:

$$\begin{aligned} &\frac{1}{2} \sqrt{f^2 + g^2} [\tilde{Q}_a(q_h) + \cos 2\theta_w Q_a(q_h)] \cdot \bar{q}_h \gamma^\mu q_h Z_\mu^a \\ &\text{where } \sin \theta_w = \frac{f}{\sqrt{f^2 + g^2}}, \quad h = L, R \end{aligned}$$

and $Q_a(q_h)$ and $\tilde{Q}_a(q_h)$ are c -numbers tabulated in Table (4)), page (17) for q ranging over leptons and quarks.

The quark anti-quark interactions with massless gauge bosons (gluons [26, 27, 28, 29]) and the associated gauge group is beyond the scope of the present communication which is restricted to the electroweak interactions and phenomenological aspects of nuclear forces only.

However it may be mentioned that the quark antiquark interactions are such that they give rise to protons p, p' and neutrons n, n' , all with baryonic number $B = 1$. When viewed in light of the first or second kind ($\mathcal{A}_\mu^1, \mathcal{A}_\mu^2$ resp.) these composite particles have charges and designations as tabulated in Table (3), page (7). This concept is illustrated in Fig.(1), page (9) and Fig. (7), page (25).

composite particle	name given when viewed with \mathcal{A}_μ^1 [nomenclature used here]	Q_1 charge	Q_2 charge	name given when viewed with \mathcal{A}_μ^2
$u_2 d_2 u_1^*$	n	0	1	p'
$u_2 d_2 d_1^*$	p	1	1	p
$u_1^* d_1^* u_2$	p'	1	0	n
$u_1^* d_1^* d_2$	n'	0	0	n'

Table (3)

Note that the designation of a composite particle is *proton* when its associated charge $Q_1 = 1$, and *neutron* when its associated charge $Q_1 = 0$. Conformity with the usual notation, in which the experimentally observed stable proton p and unstable neutron n appear unprimed can not be maintained for all scenarios discussed in the following. This is because, in this model there is another proton p' and another neutron n' , whose designations are primed [not to be confused with the prime operation on Dirac spinors defined by equation (2)].

Three possible scenarios (Y, X_1, X_2) arise naturally in the model.

Scenario: Y : In this scenario it is assumed that $m(u_1), m(d_1) \ll m(u_2), m(d_2)$ which implies that $m(p), m(n) \gg m(p'), m(n')$. Comparison of the observed value for R (5) with the value calculated in this scenario suggests that the quarks have "color" and that the number of quark colors is 2. However this scenario violates some aspects of left-right symmetry in the model at a fundamental level which is against the "*raison de etre*" for the model. We briefly mention that models demonstrating confinement of two colors were constructed some time ago [30, 31]. This is in striking contrast with the situation for three colors which have never been shown to exhibit confinement. However we shall not present an investigation of this scenario in the present communication which deals with the X scenarios described below.

Scenario X_1 : In this scenario $m(n') = m(p)$ and $m(p') = m(n)$. It arises from imposing a symmetry constraint $m(u_1) = m(u_2)$ and $m(d_1) = m(d_2)$ together with a constraint on the values of g, f , and the independent mass ratios among the masses $[m(u_1), m(d_1), m(W), m(e), m(Z)]$.

Scenario X_2 : In this scenario $m(n) = m(n')$ and $m(p) = m(p')$. It arises from imposing a symmetry constraint $m(u_1) = m(d_2)$ and $m(u_2) = m(d_1)$ together with another constraint

on the values of g , f , and the independent mass ratios among the masses [$m(u_1)$, $m(u_2)$, $m(W)$, $m(e)$, $m(Z)$]. This scenario is in apparent disagreement with observations: see section (5) on page (27) for a discussion of the X scenarios.

The model satisfies the requirements for a renormalizable quantum field theory [32, 33, 34, 35]. In particular, divergences due to anomalous Feynman diagrams (Adler-Bell-Jackiw anomalies) [36, 37, 38, 39, 40] cancel. These divergences cancel separately for the leptons and quarks, quite unlike the situation in the standard model. Therefore imposing the requirement that these divergences cancel among the leptons and quarks in a single family do not restrict the number of colors for quarks and leptons to any specific values. In the standard model, however, these values are 3 and 1 respectively. Following the usual practice, we have to check that the experimentally measured ratio,

$$R = \frac{e_1^+ + e_1^- \longrightarrow \text{hadrons}}{e_1^+ + e_1^- \longrightarrow \mu_1^+ + \mu_1^-} \quad (5)$$

at center of mass energy T , be in reasonable agreement with the value of $\sum_q Q_1^2(q)$, where q ranges over all leptons and quarks of mass $< T/2c^2$. This requirement constrains the model (in scenarios X_a) to have one color for each of the quarks and leptons. With this value for the number of quark colors, we find that when T lies between the threshold energies for τ lepton production and bottom quark (b) production, the value of $\sum_q Q_1^2(q)$ is $\frac{47}{9}$ (if we assume that production of only two charged neutrinos is effective in this energy region). This value is in better agreement with the SLAC data [41], than the value found in the standard model ($\frac{13}{3}$) - see [42].

Finally a very interesting feature of the model is that it predicts a charged neutrino, which is coupled to both kinds of photons. This has experimental and theoretical consequences which are discussed in the section (10).

3 Deductive Construction of the Model

We present the construction in three stages, outlined here:

- In stage (1) we construct the invariants under R_1 and R_2 , but ignore the groups U_1 and U_2 .
- Then, in stage (2) we introduce the two gauge groups of phase transformations U_1 and U_2 , and their associated gauge fields B_μ^1 and B_μ^2 . Additional terms in the invariants constructed in stage (1) are then deduced, so as to satisfy the following three requirements:
 1. Each of the groups U_1 and U_2 commute with both the groups R_1 and R_2 .
 2. Parity is conserved in interactions of each of the photons, i.e. that $Q_a(q_L) = Q_a(q_R)$, where $a = 1, 2$ and q varies over quarks and leptons.
 3. All divergences in anomalous Feynman diagrams mutually cancel.

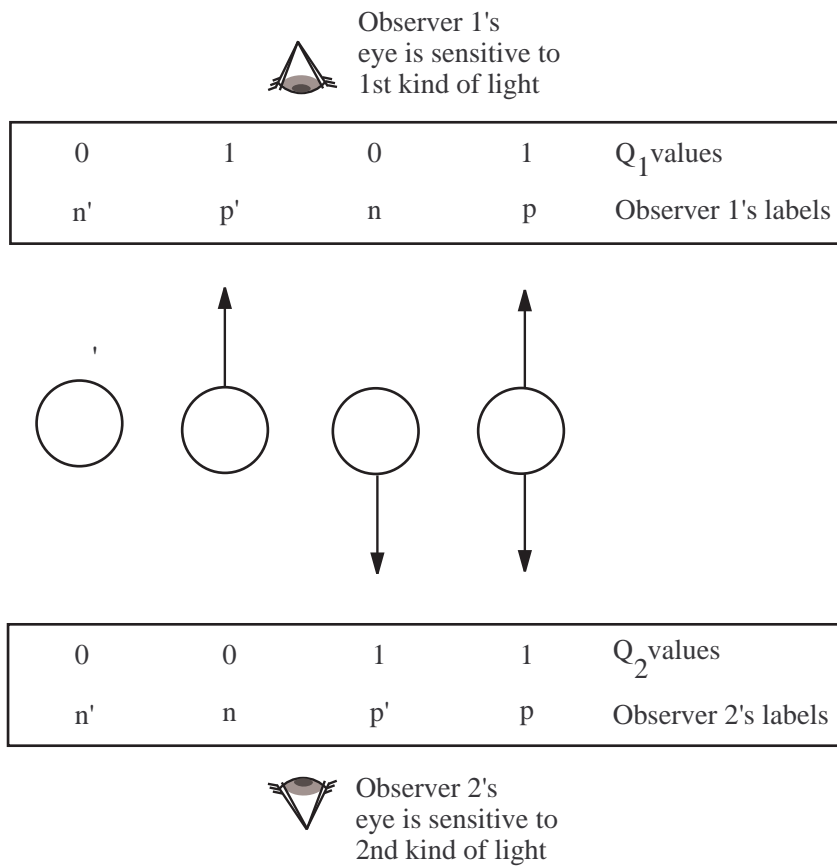


Figure 1: Differing Perspectives of Observers

- Finally, in stage (3), section (3.3) we review stages (1) and (2) in order to define those aspects of the model pertaining to these stages which could not be specified until the developments in stage (2) were presented. At this final stage the compelling necessity of pairs of families of quarks and leptons is established.

The discussion of the "parity" transformation in section (3.4) on page (20) corroborates the main results of the sections (3.2) and (3.3).

3.1 Stage (1)

We begin by considering the possible choices for the construction of invariants under R_1 and R_2 in the model. In what follows, a quark or lepton spinor projection with a definite handedness $h = (L \text{ or } R)$ will be called an *object*.

3.1.1 Construction of Invariants

We first mention that for each choice of a gauge field A_μ^i , from among the gauge fields ($W_\mu^{a,i}$) introduced earlier, the transformations of A_μ^i occur under the action of only one gauge group R , from among the gauge groups (R_1, R_2). This group R (with generators R^i) is that corresponding to the gauge field A_μ^i , with coupling constant g .

[Cautionary remark: A_μ^i and B_μ^i are generic notations introduced in this section only and are not to be confused with the electromagnetic fields \mathcal{A}_μ^a and gauge fields B_μ^a associated with the gauge groups U_a , everywhere else.]

The infinitesimal transformation $1 + \theta^i R^i$ of R acting on A_μ^i will be assumed to always act as follows:

$$A_\mu^i \rightarrow A_\mu^i + \epsilon^{ijk} \theta^j A_\mu^k + \frac{1}{g} \partial_\mu \theta^i \quad (6)$$

In contrast to this universal behavior of A_μ^i , the transformations of Dirac spinors (q, r, s etc) are determined by the various possible choices for invariants given below. These invariants involve *bilinears* of Dirac *spinors* and gauge fields. In each case of a possible invariant given in the following, the corresponding actions of the infinitesimal transformations on the various spinors occurring in the invariant will also be given for a complete description of the invariant. A *basic invariant* for R_1, R_2 involves a pair of objects (q_h, r_h) which are either both quarks or both leptons (not necessarily of the same family and not necessarily both primed or both unprimed). The members of the pair may have *different* handedness h . This pair of objects may be associated with any one of the gauge fields ($W_\mu^{a,i}$). For each choice of gauge field (A_μ^j) there is a unique possibility for constructing a basic invariant involving the pair of leptons or quarks of definite handedness.

1 Basic Invariant.

The objects considered in this and the following subsection (3.1.2) have the same handedness [different handedness is possible also - however, it is introduced only in the subsection on standard invariants (3.1.3)]. Thus one or both the objects may be primed objects with the same handedness (see equation (2) for definition of primed object) i.e. the pair

of objects is either $\begin{pmatrix} q_h \\ r_h \end{pmatrix}$ or $\begin{pmatrix} q_h \\ r'_h \end{pmatrix}$ or $\begin{pmatrix} q'_h \\ r'_h \end{pmatrix}$. In the first case (and similarly for the other cases), the invariant is

$$A.H. [i(\bar{q}_h, \bar{r}_h)(\gamma^\mu \partial_\mu - \frac{ig}{2}\sigma^i(\xi_1, \xi_2)A_\mu^j) \begin{pmatrix} q_h \\ r_h \end{pmatrix}] \quad (7)$$

where

$$\begin{aligned} \sigma^i(\xi_1, \xi_2) &= [\delta_2^i + \xi_1(1 - \delta_2^i)]\tau^{-1}(\xi_2)\sigma^i\tau(\xi_2) \\ \tau(\xi_2) &= \begin{pmatrix} \xi_2^* & 0 \\ 0 & \xi_2 \end{pmatrix}, \quad \xi_1 = \pm 1, \quad |\xi_2| = 1 \end{aligned} \quad (8)$$

[A.H. is defined by equation (3).]

This is an invariant if we require that under the action of the infinitesimal element $(1 + \theta^i R^i)$ of the group R, q_h and r_h transform as follows:

$$\begin{pmatrix} q_h \\ r_h \end{pmatrix} \rightarrow [I + \frac{i}{2}\theta^i \sigma^i(\xi_1, \xi_2)] \begin{pmatrix} q_h \\ r_h \end{pmatrix} \quad (9)$$

We refer to the term (7) as a *basic linkage* between A_μ^i and (q_h, r_h) . This type of linkage will be depicted as

$$A_\mu[\xi_1, \xi_2] \left\{ \begin{array}{c} q_h \\ r_h \end{array} \right.$$

Fig. (2): Basic Linkage

when displaying the invariants in a pictorial representation of the Lagrangian.

2 Alternative form of Basic Invariant

Another form of the basic invariant involving one gauge field and two objects of the same handedness (one or both of which may be primed) is now given. This form is more explicit and convenient to use.

$$\begin{aligned} A.H. [i\bar{q}_h \gamma^\mu \{ \partial_\mu q_h + \frac{ig}{2}\eta_1 A_\mu^3 q_h \\ - \frac{ig}{2}\eta_2 (A_\mu^2 + i\eta_1 A_\mu^1) r_h \} \\ + i\bar{r}_h \gamma^\mu \{ \partial_\mu r_h - \frac{ig}{2}\eta_1 A_\mu^3 r_h \\ - \frac{ig}{2}\eta_2^* (A_\mu^2 - i\eta_1 A_\mu^1) q_h \}] \end{aligned} \quad (10)$$

$$\text{where } \eta_1 = \xi_1, \quad \eta_2 = -i(\xi_2)^2$$

$$\text{so that } \eta_1 = \pm 1, \quad |\eta_2| = 1$$

and the associated transformations of q_h and r_h under an infinitesimal element $(1 + \theta^i R^i)$ of R are given by

$$\begin{aligned} q_h &\rightarrow q_h - \frac{i}{2}\eta_1\theta^3q_h \\ &\quad + \frac{i}{2}\eta_2(\theta^2 + i\eta_1\theta^1)r_h \\ r_h &\rightarrow r_h + \frac{i}{2}\eta_1\theta^3r_h \\ &\quad + \frac{i}{2}\eta_2^*(\theta^2 - i\eta_1\theta^1)q_h \end{aligned} \quad (11)$$

The invariant linkage (10) between A_μ^i and (q_h, r_h) will be depicted graphically as follows:

$$A_\mu[\xi_1, \xi_2] \begin{bmatrix} q_h \\ r_h \end{bmatrix}$$

Fig. (3): Alternative Form of Basic Linkage

Parentetical remarks:

1) Notice that the equivalence of the two forms of the basic invariant (7 and 10) introduced above is expressed by

$$A_\mu[\xi_1, \xi_2] \begin{bmatrix} q_h \\ r_h \end{bmatrix} = A_\mu[\eta_1, \eta_2] \begin{bmatrix} q_h \\ r_h \end{bmatrix}$$

$$\text{where } \eta_1 = \xi_1, \quad \eta_2 = -i(\xi_2)^2$$

2) Notice that variations (11) imply

$$\begin{aligned} q'_{\tilde{h}} &\rightarrow q'_{\tilde{h}} + \frac{i}{2}\eta_1\theta^3q'_{\tilde{h}} \\ &\quad - \frac{i}{2}\eta_2^*(\theta^2 - i\eta_1\theta^1)r'_{\tilde{h}} \\ r'_{\tilde{h}} &\rightarrow r'_{\tilde{h}} - \frac{i}{2}\eta_1\theta^3r'_{\tilde{h}} \\ &\quad - \frac{i}{2}\eta_2(\theta^2 + i\eta_1\theta^1)q'_{\tilde{h}} \end{aligned} \quad (12)$$

where $h = L$ or R and $\tilde{L} = R$, $\tilde{R} = L$

Also, because of the equivalence of the variations (11) and (12), the previously defined graphic notation allows us to write:

$$A_\mu[\eta_1, \eta_2] \begin{bmatrix} q_h \\ r'_h \end{bmatrix} = A_\mu[-\eta_1, -\eta_2^*] \begin{bmatrix} q'_h \\ r_h \end{bmatrix}$$

$$A_\mu[\eta_1, \eta_2] \begin{bmatrix} q'_h \\ r'_h \end{bmatrix} = A_\mu[-\eta_1, -\eta_2^*] \begin{bmatrix} q_h \\ r_h \end{bmatrix}$$

3.1.2 Extended Invariants

The invariant next in the order of length is now described. An *extended invariant* for the commuting groups R_1, R_2 involves *two* pairs of objects (q_h, r_h) , and (q_h, s_h) having one member in common. All objects involved in an extended invariant may have *different* handedness. In the following description of the invariant, however, we shall take them to have the same handedness h and they are either all quarks or all leptons. In each pair, one or both objects may be primed ($'$) or unprimed.

Each pair of objects may be associated with any one of the gauge fields $(W_\mu^{a,j}, a = 1, 2)$ introduced earlier, so long as the two pairs are associated with different gauge fields. For each choice of distinct gauge fields A_μ^i and B_μ^i , associating A_μ^i with (q_h, r_h) and B_μ^i with (q_h, s_h) we get the following invariant.

$$\begin{aligned}
A.H. \left[i\bar{q}_h \gamma^\mu \left\{ (\partial_\mu + \frac{ig}{2}\xi_1 A_\mu^3) q_h \right. \right. \\
- \frac{ig}{2}\xi_2 (A_\mu^2 + i\xi_1 A_\mu^1) r_h \\
+ \frac{ig}{2}\eta_1 B_\mu^3 q_h - \frac{ig}{2}\eta_2 (B_\mu^2 + i\eta_1 B_\mu^1) s_h \left. \right\} \\
+ i\bar{r}_h \gamma^\mu \left\{ (\partial_\mu - \frac{ig}{2}\xi_1 A_\mu^3) r_h \right. \\
- \frac{ig}{2}\xi_2^* (A_\mu^2 - i\xi_1 A_\mu^1) q_h \left. \right\} \\
+ i\bar{s}_h \gamma^\mu \left\{ (\partial_\mu - \frac{ig}{2}\eta_1 B_\mu^3) s_h \right. \\
- \frac{ig}{2}\eta_2^* (B_\mu^2 - i\eta_1 B_\mu^1) q_h \left. \right\} \Big]
\end{aligned} \tag{13}$$

where $\xi_1, \xi_2, \eta_1, \eta_2$ are independent,
 $\xi_1 = \pm 1, |\xi_2| = 1, \eta_1 = \pm 1, |\eta_2| = 1$.

The associated transformations of q_h, r_h and s_h under an infinitesimal element $(1 + \theta_1^i T^i + \theta_2^i S^i)$ of R_1 and R_2 (with generators T^i and S^i) are given by

$$\begin{aligned}
q_h &\rightarrow q_h - \frac{i}{2}\xi_1 \theta_1^3 q_h + \frac{i}{2}\xi_2 (\theta_1^2 + i\xi_1 \theta_1^1) r_h \\
&\quad - \frac{i}{2}\eta_1 \theta_2^3 q_h + \frac{i}{2}\eta_2 (\theta_2^2 + i\eta_1 \theta_2^1) s_h \\
r_h &\rightarrow r_h + \frac{i}{2}\xi_1 \theta_1^3 r_h + \frac{i}{2}\xi_2^* (\theta_1^2 - i\xi_1 \theta_1^1) q_h \\
s_h &\rightarrow s_h + \frac{i}{2}\eta_1 \theta_2^3 s_h + \frac{i}{2}\eta_2^* (\theta_2^2 - i\eta_1 \theta_2^1) q_h
\end{aligned} \tag{14}$$

We refer to the term (13) as an *extended linkage* between $A_\mu^i, (q_h, r_h)$ and $B_\mu^i, (q_h, s_h)$.

When displaying the invariants in the Lagrangian, this type of linkage will be depicted in the manner shown in Figure(4).

$$\mathcal{B}_\mu[\eta_1, \eta_2] \left[\begin{array}{c} A_\mu[\xi_1, \xi_2] \left[\begin{array}{c} q_h \\ r_h \\ s_h \end{array} \right] \end{array} \right]$$

Figure (4): Extended Linkage

[Cautionary remark: Notice that the transformations of the objects in extended invariants are different from those of the objects in basic invariants. Therefore one must not combine basic and extended invariants into the same Lagrangian if the two kinds of invariants have objects in common.]

3.1.3 Standard Invariants

The Lagrangian of elementary particle interactions according to the present model is composed exclusively of standard invariants defined in the following. A *standard invariant* for R_1, R_2 involves a *doublet of pairs*: i.e. one pair of objects $(q_h, r_{h'})$ (which may have different handedness h, h') and another pair of objects with handedness opposite to that of the first pair, viz. $(s_{\tilde{h}}, t_{\tilde{h}'})$, where q, r, s, t are either all leptons or all quarks.

Each doublet of ordered pairs above may be associated with any ordered pair $(A_\mu^i, \mathcal{B}_\mu^i)$ of distinct gauge fields from the $(W_\mu^{a,i})$. Each such association gives rise to an invariant. One of the two possible invariants thus arising is given below.

$$\begin{aligned} A.H. \left[i(\bar{q}_h \quad \bar{r}_{h'}) \gamma^\mu \{ \partial_\mu \left(\begin{array}{c} q_h \\ r_{h'} \end{array} \right) \right. \\ - \frac{ig}{2} \sigma^j(\xi_1, \xi_2) A_\mu^j \left(\begin{array}{c} q_h \\ r_{h'} \end{array} \right) - \frac{ig}{2} \eta_1 \mathcal{B}_\mu^3 \left(\begin{array}{c} q_h \\ r_{h'} \end{array} \right) \\ - \frac{ig}{2} \eta_2 (\mathcal{B}_\mu^2 + i\eta_1 \mathcal{B}_\mu^1) \left(\begin{array}{c} t'_{h'} \\ -s'_h \end{array} \right) \} \\ \left. + i(\bar{s}_{\tilde{h}} \quad \bar{t}_{\tilde{h}'}) \gamma^\mu \{ \partial_\mu \left(\begin{array}{c} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{array} \right) \right. \\ - \frac{ig}{2} \sigma^j(\xi_1, \xi_2) A_\mu^j \left(\begin{array}{c} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{array} \right) - \frac{ig}{2} \eta_1 \mathcal{B}_\mu^3 \left(\begin{array}{c} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{array} \right) \\ \left. - \frac{ig}{2} \eta_2 (\mathcal{B}_\mu^2 + i\eta_1 \mathcal{B}_\mu^1) \left(\begin{array}{c} r'_{\tilde{h}'} \\ -q'_{\tilde{h}} \end{array} \right) \} \right] \end{aligned} \quad (15)$$

This linkage is represented diagrammatically as follows:

$$\mathcal{B}_\mu[\eta_1, \eta_2] \begin{bmatrix} A_\mu[\xi_1, \xi_2] \begin{Bmatrix} q_h \\ r_{h'} \end{Bmatrix} \\ A_\mu[\xi_1, \xi_2] \begin{Bmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{Bmatrix} \end{bmatrix}$$

Figure 5: Standard Linkage

The associated transformations of q_h , $r_{h'}$, $s_{\tilde{h}}$ and $t_{\tilde{h}'}$ under an infinitesimal element $(1 + \theta_1^i T^i + \theta_2^i S^i)$ of R_1 and R_2 are given by

$$\begin{aligned} \begin{pmatrix} q_h \\ r_{h'} \end{pmatrix} &\rightarrow \begin{pmatrix} q_h \\ r_{h'} \end{pmatrix} + \frac{i}{2} \theta_1^i \sigma^i(\xi_1, \xi_2) \begin{pmatrix} q_h \\ r_{h'} \end{pmatrix} \\ &+ \frac{i}{2} \eta_1 \theta_2^3 \begin{pmatrix} q_h \\ r_{h'} \end{pmatrix} + \frac{i}{2} \eta_2 (\theta_2^2 + i \eta_1 \theta_2^1) \begin{pmatrix} t'_{h'} \\ -s'_h \end{pmatrix} \end{aligned} \quad (16)$$

$$\begin{aligned} \begin{pmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{pmatrix} &\rightarrow \begin{pmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{pmatrix} + \frac{i}{2} \theta_1^i \sigma^i(\xi_1, \xi_2) \begin{pmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{pmatrix} \\ &+ \frac{i}{2} \eta_1 \theta_2^3 \begin{pmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{pmatrix} + \frac{i}{2} \eta_2 (\theta_2^2 + i \eta_1 \theta_2^1) \begin{pmatrix} r'_{\tilde{h}'} \\ -q'_h \end{pmatrix} \end{aligned}$$

We refer to the term (15) as a *Standard Linkage* (SL) between $A_\mu^j, \mathcal{B}_\mu^j$, $(q_h, r_{h'})$, and $(s_{\tilde{h}}, t_{\tilde{h}'})$.

Notice that when $h \neq h'$ the invariant (15) reduces to become

$$\begin{aligned} A.H. &\left[i(\bar{q}_h \quad \bar{r}_{h'}) \gamma^\mu \{ \partial_\mu \begin{pmatrix} q_h \\ r_{h'} \end{pmatrix} \right. \\ &- \frac{ig}{2} \sigma^3(\xi_1, \xi_2) A_\mu^3 \begin{pmatrix} q_h \\ r_{h'} \end{pmatrix} - \frac{ig}{2} \eta_1 \mathcal{B}_\mu^3 \begin{pmatrix} q_h \\ r_{h'} \end{pmatrix} \} \\ &+ i(\bar{s}_{\tilde{h}} \quad \bar{t}_{\tilde{h}'}) \gamma^\mu \{ \partial_\mu \begin{pmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{pmatrix} \\ &\left. - \frac{ig}{2} \sigma^3(\xi_1, \xi_2) A_\mu^3 \begin{pmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{pmatrix} - \frac{ig}{2} \eta_1 \mathcal{B}_\mu^3 \begin{pmatrix} s_{\tilde{h}} \\ t_{\tilde{h}'} \end{pmatrix} \} \right] \end{aligned} \quad (17)$$

See equation (47) in the Appendix, page (39).

Given a linkage L , which is of any one of the previously described types, we define its *domain* $\mathbf{D}(L)$ to be the set of quarks or leptons associated with L .

We can now describe the first two terms in the Lagrangian which are invariant under R_1 and R_2 . These four terms arise from Standard Linkages between

$$\begin{aligned} W_\mu^{1j}, W_\mu^{2j}, (\nu_L^{e_1}, e_{1L}) \quad \text{and} \quad (\nu_R^{e_2}, e_{2R}); \\ W_\mu^{1j}, W_\mu^{2j}, (u_{1L}, d_{1L}) \quad \text{and} \quad (u_{2R}, d_{2R}). \end{aligned}$$

All these linkages have the values for the parameters $\xi_1, \xi_2, \eta_1, \eta_2$ all set equal to +1 as depicted in the diagrammatic representation of the Lagrangian (31).

We now mention that at this first stage of construction of the model the transformation properties of the multiplets $(\nu_R^{e_1}, e_{1R}, \nu_L^{e_2}, e_{2L})$ and $(u_{1R}, d_{1R}, u_{2L}, d_{2L})$ under the actions of the generators of R_1 and R_2 have not been specified. This will be done in section (3.3) after we become familiar with the contents of sections (3.2).

3.2 Stage (2)

In this stage, we introduce two gauge groups of phase transformations U_1 and U_2 , together with their associated gauge fields B_μ^1 and B_μ^2 . The linkage terms described in the previous section (3.1) are now augmented so as to make them invariant under U_1 and U_2 , while satisfying the three conditions formulated in section (3), paragraph (3), page (8).

First, we require that each of the groups U_1 and U_2 commute with both the groups R_1 and R_2 . This requirement can be satisfied by adding the following term to each previously described linkage L :

$$f \sum_{\substack{q_h \text{ in } \mathbf{D}(L) \\ a=1,2}} c_a(q_h) \cdot \bar{q}_h \gamma^\mu q_h B_\mu^a \quad (18)$$

(Here the $c_a(q_h)$ are c -numbers.) In particular, if L is a basic linkage or an extended linkage, then the $c_a(q_h)$ do not depend on q_h . In contrast, for a standard linkage, between say (q_L, r_L) and (s_R, t_R) , the $c_a(q_h)$ have a dependence on q_h expressed by

$$c_a(q_L) = c_a(r_L) = -c_a(s_R) = -c_a(t_R) \quad (19)$$

We refer to the invariants obtained by adding term (18) to each of the terms (7), (10), (13), (15) as *augmented linkages* of various types. The augmented standard linkages are represented diagrammatically as follows:

$$\mathcal{B}_\mu[\eta_1, \eta_2] \left[\begin{array}{l} A_\mu[\xi_1, \xi_2] \left\{ \begin{array}{lll} q_h & c_1(q_h) & c_2(q_h) \\ r_{h'} & c_1(r_{h'}) & c_2(r_{h'}) \end{array} \right. \\ \\ A_\mu[\xi_1, \xi_2] \left\{ \begin{array}{lll} s_{\tilde{h}} & c_1(s_{\tilde{h}}) & c_2(s_{\tilde{h}}) \\ t_{\tilde{h}'} & c_1(t_{\tilde{h}'}) & c_2(t_{\tilde{h}'}) \end{array} \right. \end{array} \right]$$

Fig.(6):Augmented Standard Linkage

Second, we must ensure that parity is conserved in interactions of each of the photons. We know from experimental evidence that the second photon \mathcal{A}_μ^2 does not interact with the electron e_1 —so we expect, by symmetry, that the photon \mathcal{A}_μ^1 does not interact with the electron e_2 . This suggests that we define the photons in the model to be orthogonal to

$$gW_\mu^{a,3} - fB_\mu^a \quad (a = 1, 2)$$

Hence,

$$\mathcal{A}_\mu^a = \sin \theta_w W_\mu^{a,3} + \cos \theta_w B_\mu^a \quad (20)$$

where

$$\sin \theta_w = \frac{f}{\sqrt{f^2 + g^2}}$$

$$\cos \theta_w = \frac{g}{\sqrt{f^2 + g^2}}$$

q_h	$c_1(q_h)$	$c_2(q_h)$	$c_3(q_h)$	$c_4(q_h)$	$Q_1 = c_5(q_h)$	$Q_2 = c_6(q_h)$	$\tilde{Q}_1 = c_7(q_h)$	$\tilde{Q}_2 = c_8(h)$
$\nu_L^{e_1}$	-1/2	-1/2	1/2	1/2	0	0	1	1
e_{1L}	-1/2	-1/2	-1/2	1/2	-1	0	0	1
$\nu_R^{e_1}$	-1/2	-1/2	1/2	1/2	0	0	1	1
e_{1R}	-1/2	-1/2	-1/2	1/2	-1	0	0	1
$\nu_R^{e_2}$	1/2	1/2	1/2	1/2	1	1	0	0
e_{2R}	1/2	1/2	-1/2	1/2	0	1	-1	0
$\nu_L^{e_2}$	1/2	1/2	1/2	1/2	1	1	0	0
e_{2L}	1/2	1/2	-1/2	1/2	0	1	-1	0
u_{1L}	-1/6	-1/6	1/2	1/2	1/3	1/3	2/3	2/3
d_{1L}	-1/6	-1/6	-1/2	1/2	-2/3	1/3	-1/3	2/3
u_{1R}	-1/6	-1/6	1/2	1/2	1/3	1/3	2/3	2/3
d_{1R}	-1/6	-1/6	-1/2	1/2	-2/3	1/3	-1/3	2/3
u_{2R}	1/6	1/6	1/2	1/2	2/3	2/3	1/3	1/3
d_{2R}	1/6	1/6	-1/2	1/2	-1/3	2/3	-2/3	1/3
u_{2L}	1/6	1/6	1/2	1/2	2/3	2/3	1/3	1/3
d_{2L}	1/6	1/6	-1/2	1/2	-1/3	2/3	-2/3	1/3

Table (4)

θ_w is the analogue of the angle θ_W in the standard model [18]. We further define

$$\mathcal{Z}_\mu^a = \cos \theta_w W_\mu^{a,3} - \sin \theta_w B_\mu^a$$

Re-expressing the augmented linkages in terms of the just defined \mathcal{A}_μ^a and \mathcal{Z}_μ^a , it is easy to verify that \mathcal{A}_μ^a only occurs in terms of the form $\frac{1}{2}\sqrt{f^2 + g^2} \sin 2\theta_w Q_a(q_h) \cdot \bar{q}_h \gamma^\mu q_h \mathcal{A}_\mu^a$, and \mathcal{Z}_μ^a occurs exclusively in terms of the form $\frac{1}{2}\sqrt{f^2 + g^2}(\tilde{Q}_a(q_h) + \cos 2\theta_w Q_a(q_h)) \cdot \bar{q}_h \gamma^\mu q_h \mathcal{Z}_\mu^a$. [Here $Q_a(q_h)$ and $\tilde{Q}_a(q_h)$ are c -numbers tabulated in Table (4) for a Standard Linkage between W_μ^{1j}, W_μ^{2j} , $(\nu_{L(R)}^{e_1}, e_{1L(R)})$ and $(\nu_{R(L)}^{e_2}, e_{2R(L)})$ respectively and a Standard Linkage between W_μ^{1j}, W_μ^{2j} , $(u_{1L(R)}, d_{1L(R)})$ and $(u_{2R(L)}, d_{2R(L)})$ respectively.]

Parity conservation, whose precise notion in the model is given in section (3.4) page (20), is implemented by setting

$$Q_a(q_L) = Q_a(q_R) \quad (21)$$

where $a = 1, 2$ and q varies over quarks and leptons.

Finally, we require that all divergences in anomalous Feynman diagrams [38, 39, 40] mutually cancel. This implies that all matrices $V_1, V_2, (A)$ associated with vector (axial vector) bilinears occurring at vertices in triangular Feynman diagrams with external lines of gauge bosons in the model must satisfy:

$$Tr [(V_1 V_2 + V_2 V_1), A] = 0$$

which in turn implies that for all $a, b, c = 1, 2$

$$\sum_q Q_a(q_h) Q_b(q_h) (\tilde{Q}_c(q_L) - \tilde{Q}_c(q_R)) = 0 \quad (22)$$

Parentetical remark: [We shall see later that according to the precise notion of "parity symmetry" in the model introduced in section (3.4), page (20) we have $\tilde{Q}_a(q_L) = \tilde{Q}_a(q_R)$. Thus the conditions (22) implied by the cancellation of infinities in anomalous Feynman diagrams [38, 39, 40] are guaranteed when "parity symmetry" for the model is implemented. However at this stage we need not invoke the complete notion of "parity symmetry" to be introduced later.]

In order to be in agreement with the specifications in the standard model, we take

$$Q_1(e_1) = -1, \quad Q_1(u_1) - Q_1(d_1) = +1 \quad (23)$$

The constraints (19), (20), (21), (22), and (23) along with the fundamental requirement that baryons of integral charge and composed of three quarks be allowed in the model then *uniquely* determine the values of the coefficients, $c_i(q_h)$ ($i = 1 - 4$) of the diagonal terms $\bar{q}_h \gamma^\mu q_h V_\mu^i$ appearing in the Lagrangian. V_μ^i ranges over $fB_\mu^1, fB_\mu^2, gW_\mu^{13}, gW_\mu^{23}$ which are denoted, respectively, by V_μ^i ($i = 1 - 4$). These values $c_i(q_h)$, deduced for members of the first family under consideration, are tabulated in Table (4), page (17). In Table (4), c_5, c_6, c_7, c_8 are defined as follows:

$$\begin{aligned} c_5 &= c_3 + c_1, & c_6 &= c_4 + c_2 \\ c_7 &= c_3 - c_1, & c_8 &= c_4 - c_2 \end{aligned}$$

Notice that at stage (1) we did not specify the transformations under the actions of R_1, R_2 for the multiplets $(\nu_R^{e1}, e_{1R}, \nu_L^{e2}, e_{2L})$ and $(u_{1R}, d_{1R}, u_{2L}, d_{2L})$. However we have just determined the actions of U_1 and U_2 on these multiplets which are specified by the values of c_1 and c_2 given in Table (4). We shall take the constraint provided by the actions of U_1 and U_2 on the multiplets into account in stage (3) to determine the actions of R_1 and R_2 on these multiplets. The latter set of actions must commute with the former.

3.3 Stage (3)

In this final stage completing the construction of the part of the model not involving Higgs scalars [21, 22, 23, 24, 25], we would determine the transformation properties under R_1 , R_2 , of the multiplets $(\nu^{e_1}_{1R}, e_{1R}, \nu^{e_2}_{2L}, e_{2L})$, $(u_{1R}, d_{1R}, u_{2L}, d_{2L})$ and the associated invariant terms in the Lagrangian.

To do this, we refer to the following guidelines:

1) The actions of U_a (with infinitesimal generators $1 + i\varepsilon_a U^a$) on the multiplets were found in section(3.2, 16 to be given by

$$q_h \rightarrow q_h - i c_a(q_h) \varepsilon_a q_h$$

where $c_a(q_h)$ are tabulated in Table (4).

2) The actions just mentioned in (1) must commute with the actions of R_1 and R_2 to be found.

3) The actions of R_1 and R_2 are determined by the choice of invariants linking the multiplets. This choice must be such that it reproduces the specific feature of the standard model involving e_{1R} (the right-handed projection of the usual electron): viz., e_{1R} is not coupled to the charged vector bosons $W_\mu^{a\pm}$ since there are no right-handed weak currents manifested in the phenomenology of weak interactions involving electrons [45].

It can be shown that it is not possible to satisfy the three guidelines given above within the framework of the family of leptons and quarks introduced so far. However, it is possible to do so if we introduce a new family of leptons and quarks for which the set of values $c_j(q_h)$, [$j = 1, 2$] are equal to those of the first family of leptons and quarks [given in Table (4)]. We designate the members of the new family by the addition of a "breve" to the symbols for the corresponding members of the first family of quarks and leptons: viz., $(\check{\nu}^{e_1}_L, \check{e}_{1L}, \check{\nu}^{e_2}_R, \check{e}_{2R})$ and $(\check{u}_{1L}, \check{d}_{1L}, \check{u}_{2R}, \check{d}_{2R})$. The "breve" family's members are arranged in their interactions with the gauge bosons analogously to the already described partial organization of the first family, except that the roles of left-handed and right-handed objects are interchanged (for the reason to emerge below). Thus the two terms in the Lagrangian involving members of the "breve" family only, arise from augmented standard linkages between

$$\begin{aligned} W_\mu^{1j}, W_\mu^{2j}, (\check{\nu}^{e_1}_R, \check{e}_{1R}) \quad \text{and} \quad (\check{\nu}^{e_2}_L, \check{e}_{2L}); \\ W_\mu^{1j}, W_\mu^{2j}, (\check{u}_{1R}, \check{d}_{1R}) \quad \text{and} \quad (\check{u}_{2L}, \check{d}_{2L}). \end{aligned} \quad (24)$$

These linkages have the values for the parameters $\xi_1, \xi_2, \eta_1, \eta_2$ all set equal to +1 as depicted in the diagrammatic representation of the Lagrangian (31).

The only remaining problem now is to specify the actions of R_1 and R_2 on

$$\begin{aligned} (\check{\nu}^{e_1}_L, \check{e}_{1L}, \check{\nu}^{e_2}_R, \check{e}_{2R}); \\ (\check{u}_{1L}, \check{d}_{1L}, \check{u}_{2R}, \check{d}_{2R}) \end{aligned} \quad (25)$$

and on

$$\begin{aligned} (\nu^{e_1}_R, e_{1R}, \nu^{e_2}_L, e_{2L}); \\ (u_{1R}, d_{1R}, u_{2L}, d_{2L}) \end{aligned} \quad (26)$$

through the appropriate choice of invariants involving the objects listed above (25, 26) so that the three guidelines are fulfilled. This is achieved through the two postulates given below:

A : The masses of the breve electrons and breve quarks are much bigger than the masses of electrons and quarks respectively.

B : There are augmented Standard Linkage between:

$$\begin{aligned}
& W_\mu^{1j}, W_\mu^{2j}, (\nu_R^{e_1}, \check{e}_{1L}) \text{ and } (\nu_L^{e_2}, \check{e}_{2R}); \\
& W_\mu^{1j}, W_\mu^{2j}, (\check{\nu}_L^{e_1}, e_{1R}) \text{ and } (\check{\nu}_R^{e_2}, e_{2L}); \\
& W_\mu^{1j}, W_\mu^{2j}, (u_{1R}, \check{d}_{1L}) \text{ and } (u_{2L}, \check{d}_{2R}); \\
& W_\mu^{1j}, W_\mu^{2j}, (\check{u}_{1L}, d_{1R}) \text{ and } (\check{u}_{2R}, d_{2L}).
\end{aligned} \tag{27}$$

with the parameters $\xi_1, \xi_2, \eta_1, \eta_2$ for all these linkages all equal to +1.

Parentetical remarks: [Augmented standard linkages (*ASL*) are described in section (3.2). Transformations of members of $\mathbf{D}(ASL)$ under $R_1, R_2; U_1, U_2$ are given in sections (3.1); (3.2). respectively. Notice that the transformations under R_1, R_2 for augmented standard linkages coincide with those for the standard linkages and are given by (16), page (15)]

In accordance with expression (17), it is now apparent that in the above linkages (27) involving object pairs with different handedness the charged weak bosons ($W_\mu^{a\pm}$) are absent, in agreement with the requirement of the third guideline. Postulate *A* further excludes low energy manifestation of couplings of charged weak bosons to right handed objects which would otherwise have been un-avoidable in view of the postulated linkages (24).

The augmented standard invariants appearing in the Lagrangian corresponding to the linkages (27) are therefore:

$$\begin{aligned}
A.H. \left[i(\overline{\nu^{e_1}_R} \quad \bar{\check{e}}_{1L}) \gamma^\mu \{ \partial_\mu \begin{pmatrix} \nu^{e_1}_R \\ \check{e}_{1L} \end{pmatrix} - \frac{ig}{2} \sigma^3 W_\mu^{13} \begin{pmatrix} \nu^{e_1}_R \\ \check{e}_{1L} \end{pmatrix} - \frac{ig}{2} W_\mu^{23} \begin{pmatrix} \nu^{e_1}_R \\ \check{e}_{1L} \end{pmatrix} \right. \\
\left. + i \frac{f}{2} B_\mu^1 \begin{pmatrix} \nu^{e_1}_R \\ \check{e}_{1L} \end{pmatrix} + i \frac{f}{2} B_\mu^2 \begin{pmatrix} \nu^{e_1}_R \\ \check{e}_{1L} \end{pmatrix} \right\} \\
+ i(\overline{\nu^{e_2}_L} \quad \bar{\check{e}}_{2R}) \gamma^\mu \{ \partial_\mu \begin{pmatrix} \nu^{e_2}_L \\ \check{e}_{2R} \end{pmatrix} - \frac{ig}{2} \sigma^3 W_\mu^{13} \begin{pmatrix} \nu^{e_2}_L \\ \check{e}_{2R} \end{pmatrix} - \frac{ig}{2} W_\mu^{23} \begin{pmatrix} \nu^{e_2}_L \\ \check{e}_{2R} \end{pmatrix} \\
\left. - i \frac{f}{2} B_\mu^1 \begin{pmatrix} \nu^{e_2}_L \\ \check{e}_{2R} \end{pmatrix} - i \frac{f}{2} B_\mu^2 \begin{pmatrix} \nu^{e_2}_L \\ \check{e}_{2R} \end{pmatrix} \right\} \Big]
\end{aligned} \tag{28}$$

+ terms obtained from previous two through the exchange ($e \rightleftharpoons \check{e}$ and $\nu \rightleftharpoons \check{\nu}$)

+ terms obtained from previous four through the substitutions ($e \rightarrow d$ and $\nu^e \rightarrow u$)

3.4 Discrete Symmetry Transformation (Parity or Mirror Reflection Analogue - MRA)

The model developed so far has the following property: for each charged weak interaction boson ($W_\mu^{a\pm}$, $a = 1, 2$) and each object with definite handedness and type ($e_1, e_2, \nu^{e_1}, \nu^{e_2}, u_1, u_2, d_1, d_2, \check{e}_1, \check{e}_2, \check{\nu}^{e_1}, \check{\nu}^{e_2}, \check{u}_1, \check{u}_2, \check{d}_1, \check{d}_2$), the boson is coupled differently to the right and left handed object of the same type. [see the terms in the Lagrangian (31) displayed in (4)]. There is,

however, a discrete symmetry transformations (Π) of the model Lagrangian constructed so far. It is given by:

$$\begin{aligned} W_\mu^{a\pm}(\vec{x}, t) &\rightarrow (\delta_\mu^0 - \Sigma_j \delta_\mu^j) W_\mu^{a\pm}(-\vec{x}, t) \\ \mathcal{Z}_\mu^a(\vec{x}, t) &\rightarrow (\delta_\mu^0 - \Sigma_j \delta_\mu^j) \mathcal{Z}_\mu^a(-\vec{x}, t) \end{aligned} \quad (29)$$

$$\mathcal{A}_\mu^a(\vec{x}, t) \rightarrow (\delta_\mu^0 - \Sigma_j \delta_\mu^j) \mathcal{A}_\mu^a(-\vec{x}, t)$$

$$\begin{aligned} e_{ah}(\vec{x}, t) &\rightarrow \begin{aligned} &\gamma^0 e_{a\tilde{h}}(-\vec{x}, t) \text{ upper mode} \\ &\gamma^0 e_{\tilde{a}\tilde{h}}(-\vec{x}, t) \text{ lower mode} \end{aligned} \\ \nu_h^{e_a}(\vec{x}, t) &\rightarrow \begin{aligned} &\gamma^0 \nu_{\tilde{h}}^{e_a}(-\vec{x}, t) \text{ upper mode} \\ &\gamma^0 \nu_{\tilde{h}}^{e_{\tilde{a}}}(-\vec{x}, t) \text{ lower mode} \end{aligned} \end{aligned} \quad (30)$$

$$u_{ah}(\vec{x}, t) \rightarrow \begin{aligned} &\gamma^0 u_{a\tilde{h}}(-\vec{x}, t) \text{ upper mode} \\ &\gamma^0 u_{\tilde{a}\tilde{h}}(-\vec{x}, t) \text{ lower mode} \end{aligned}$$

$$d_{ah}(\vec{x}, t) \rightarrow \begin{aligned} &\gamma^0 d_{a\tilde{h}}(-\vec{x}, t) \text{ upper mode} \\ &\gamma^0 d_{\tilde{a}\tilde{h}}(-\vec{x}, t) \text{ lower mode} \end{aligned}$$

and transformations obtained from (30) through the substitutions $e \rightarrow \check{e}$, $\nu \rightarrow \check{\nu}$, $u \rightarrow \check{u}$, $d \rightarrow \check{d}$

where $a = 1, 2$; $h = L, R$; $\tilde{1} = 2$, $\tilde{2} = 1$; $\tilde{L} = R$, $\tilde{R} = L$ and (\vec{x}, t) are the space and time components of space-time co-ordinates x . The factors $(\delta_\mu^0 - \Sigma_j \delta_\mu^j)$, on the right of arrows, above have the effect of making only the space components of the gauge fields to change sign on the right hand side. The upper [lower] modes of operation for the transformation is manifested in those terms (i.e. monomials) in the Lagrangian in which \mathcal{A}_μ^a , \mathcal{Z}_μ^a [W_μ^a] occurs.

The discrete symmetry transformation described above (probably) can not be represented by the action of some operator acting on the (Hilbert) space of particle states in the model. This is quite unlike the standard model where a discrete symmetry somewhat analogous to the discrete

symmetry of the Lagrangian described here is represented by an operator P in the state space. In the context of the standard model it is then meaningful to investigate P, CP, PT, CPT (non) conservation. Such questions do not seem to be well-defined in the present model. Notice, however, that the discrete transformation above applied twice is equivalent to the identity.

4 Lagrangian of the model

We shall present diagrammatic representation of the part of the model Lagrangian which does not involve the Higgs scalars [21, 22, 23, 24, 25] and the associated mass terms - i.e. we shall restrict ourselves to presenting explicitly only the left hand end of the complete Lagrangian. We shall consider the first family of leptons and quarks only. The right hand end of the Lagrangian and the associated new symmetries linking scalars, spinors and vectors is a separate topic for future presentation. Using the notation for augmented standard invariants described on page (16), the Lagrangian of the model can now be written as

$$\begin{aligned}
& W_\mu^2[1, 1] \left[\begin{array}{l} W_\mu^1[1, 1] \left\{ \begin{array}{lll} \nu^{e_1}_L & -\frac{1}{2} & -\frac{1}{2} \\ e_{1L} & -\frac{1}{2} & -\frac{1}{2} \end{array} \right. \\ W_\mu^1[1, 1] \left\{ \begin{array}{lll} \nu^{e_2}_R & \frac{1}{2} & \frac{1}{2} \\ e_{2R} & \frac{1}{2} & \frac{1}{2} \end{array} \right. \end{array} \right. \\
& + W_\mu^2[1, 1] \left[\begin{array}{l} W_\mu^1[1, 1] \left\{ \begin{array}{lll} \check{\nu}_R^{e_1} & -\frac{1}{2} & -\frac{1}{2} \\ \check{e}_{1R} & -\frac{1}{2} & -\frac{1}{2} \end{array} \right. \\ W_\mu^1[1, 1] \left\{ \begin{array}{lll} \check{\nu}_L^{e_2} & \frac{1}{2} & \frac{1}{2} \\ \check{e}_{2L} & \frac{1}{2} & \frac{1}{2} \end{array} \right. \end{array} \right. \\
& + W_\mu^2[1, 1] \left[\begin{array}{l} W_\mu^1[1, 1] \left\{ \begin{array}{lll} \nu^{e_1}_R & -\frac{1}{2} & -\frac{1}{2} \\ \check{e}_{1L} & -\frac{1}{2} & -\frac{1}{2} \end{array} \right. \\ W_\mu^1[1, 1] \left\{ \begin{array}{lll} \nu^{e_2}_L & \frac{1}{2} & \frac{1}{2} \\ \check{e}_{2R} & \frac{1}{2} & \frac{1}{2} \end{array} \right. \end{array} \right. \\
& + W_\mu^2[1, 1] \left[\begin{array}{l} W_\mu^1[1, 1] \left\{ \begin{array}{lll} \check{\nu}_L^{e_1} & -\frac{1}{2} & -\frac{1}{2} \\ e_{1R} & -\frac{1}{2} & -\frac{1}{2} \end{array} \right. \\ W_\mu^1[1, 1] \left\{ \begin{array}{lll} \check{\nu}_R^{e_2} & \frac{1}{2} & \frac{1}{2} \\ e_{2L} & \frac{1}{2} & \frac{1}{2} \end{array} \right. \end{array} \right.
\end{aligned}$$

$$\begin{aligned}
& +W_\mu^2[1,1] \left[\begin{array}{l} W_\mu^1[1,1] \left\{ \begin{array}{lll} u_{1L} & -\frac{1}{6} & -\frac{1}{6} \\ d_{1L} & -\frac{1}{6} & -\frac{1}{6} \end{array} \right. \\ W_\mu^1[1,1] \left\{ \begin{array}{lll} u_{2R} & \frac{1}{6} & \frac{1}{6} \\ d_{2R} & \frac{1}{6} & \frac{1}{6} \end{array} \right. \end{array} \right. \\
& +W_\mu^2[1,1] \left[\begin{array}{l} W_\mu^1[1,1] \left\{ \begin{array}{lll} \check{u}_{1R} & -\frac{1}{6} & -\frac{1}{6} \\ \check{d}_{1R} & -\frac{1}{6} & -\frac{1}{6} \end{array} \right. \\ W_\mu^1[1,1] \left\{ \begin{array}{lll} \check{u}_{2L} & \frac{1}{6} & \frac{1}{6} \\ \check{d}_{2L} & \frac{1}{6} & \frac{1}{6} \end{array} \right. \end{array} \right. \\
& +W_\mu^2[1,1] \left[\begin{array}{l} W_\mu^1[1,1] \left\{ \begin{array}{lll} \check{u}_{1L} & -\frac{1}{6} & -\frac{1}{6} \\ d_{1R} & -\frac{1}{6} & -\frac{1}{6} \end{array} \right. \\ W_\mu^1[1,1] \left\{ \begin{array}{lll} \check{u}_{2R} & \frac{1}{6} & \frac{1}{6} \\ d_{2L} & \frac{1}{6} & \frac{1}{6} \end{array} \right. \end{array} \right. \\
& +W_\mu^2[1,1] \left[\begin{array}{l} W_\mu^1[1,1] \left\{ \begin{array}{lll} u_{1R} & -\frac{1}{6} & -\frac{1}{6} \\ \check{d}_{1L} & -\frac{1}{6} & -\frac{1}{6} \end{array} \right. \\ W_\mu^1[1,1] \left\{ \begin{array}{lll} u_{2L} & \frac{1}{6} & \frac{1}{6} \\ \check{d}_{2R} & \frac{1}{6} & \frac{1}{6} \end{array} \right. \end{array} \right. \\
& + \text{invariants of gauge fields only} \\
& + \text{invariants involving Higgs scalars.}
\end{aligned} \tag{31}$$

5 Possible Consequences of the Results of the Model for Nuclei (and Chemistry)

This section deals mainly with exploring the consequences of the two types of protons and neutrons for nuclei. However we shall also briefly mention some consequences for chemistry to the extent that it would be helpful in clarifying the associated ideas.

We proceed by relying on a plausible heuristic model of nuclei composed of the two types of nucleons. The emphasis would be on presenting a method for deriving empirical relations for

the masses of "isomers" (i.e. nuclides with a definite atomic number Z and mass number A , but with different detailed constitutions determined by number of nucleons of each type). These mass differences are quite small and are on the borderline of limits on experimental precision in measurements of nuclear isotope masses [43].

Each nucleus of atomic number Z may have Z_1 protons (p) and Z_2 p-protons (p') where

$$Z = Z_1 + Z_2 \quad (32)$$

Parentetical remark: [the notation "p-proton" stands for primed proton (p') and "u-neutron" stands for unprimed neutron (n), proton (p) is unprimed and neutron (n') is primed.]

If the same nucleus has atomic mass number A then it may have N_1 u-neutrons (n) and N_2 neutrons (n') where

$$A - Z = N_1 + N_2 \quad (33)$$

It can be shown that the total number of isomers of a nuclide (Z, A) is

$$N_{isom.} = (A - Z + 1)(Z + 1) \quad (34)$$

These isomers would be of nearly identical masses only if p, p', n, n' are all nearly equal in mass which implies that $m(u_1), m(d_1), m(u_2), m(d_2)$ have nearly equal masses. The discussion in this paper is restricted to consideration of this possibility only. Scenario Y is not being considered here.

Thus, for example Triton ($A = 3, Z = 1$) has the six isomers shown in Figure (7) when viewed in \mathcal{A}_μ^1 . However these same nuclides when viewed in \mathcal{A}_μ^2 would appear as a mixture of isotopes of several chemically different elements.

Introduce the symbols \bigcirc and \bigcirc_\downarrow for the two kinds of neutrons (n', n), with Q_1 values (0, 0) and Q_2 values (0, 1) respectively; the symbols \bigcirc_\uparrow and \bigcirc_\downarrow for the two kinds of protons (p', p), with Q_1 values (1, 1) and Q_2 values (0, 1) respectively. Then the potential isomers for 3H_1 (Triton), possibly unstable, may be represented as shown in Figure (7).

[Notice that the middle two configurations in the top row of Figure (7) are identical and the two end configurations in the bottom row are identical, so that there are six distinct configurations (in agreement with relation (34)).]

These isomers could capture any free \bar{e}_2 's in their neighborhood. Since the \bar{e}_2 's (attached to the isomers) are coupled to \mathcal{A}_μ^2 they would provide the foundation for a parallel chemistry involving the same nuclides. This parallel or alternative chemistry ("al-chemistry" ?) would then be present in our world but its operation may not be amenable to the usual methods of chemical analysis as would become apparent from the description of scenario S_1 presented in section (6), page (30).

A collection of neutral atoms ($Q_1 = 0, Q_2 = 0$) with nuclei of atomic number Z (i.e. $Q_1 = Z, Q_2$ un-defined) and mass number A [in $(A - Z + 1)(Z + 1)$ distinct isomeric states] when illumined with light of the first kind (\mathcal{A}_μ^1) would appear as a chemically pure substance as far as chemical reactions involving e_1 and \mathcal{A}_μ^1 go. However, when viewed with light of the second

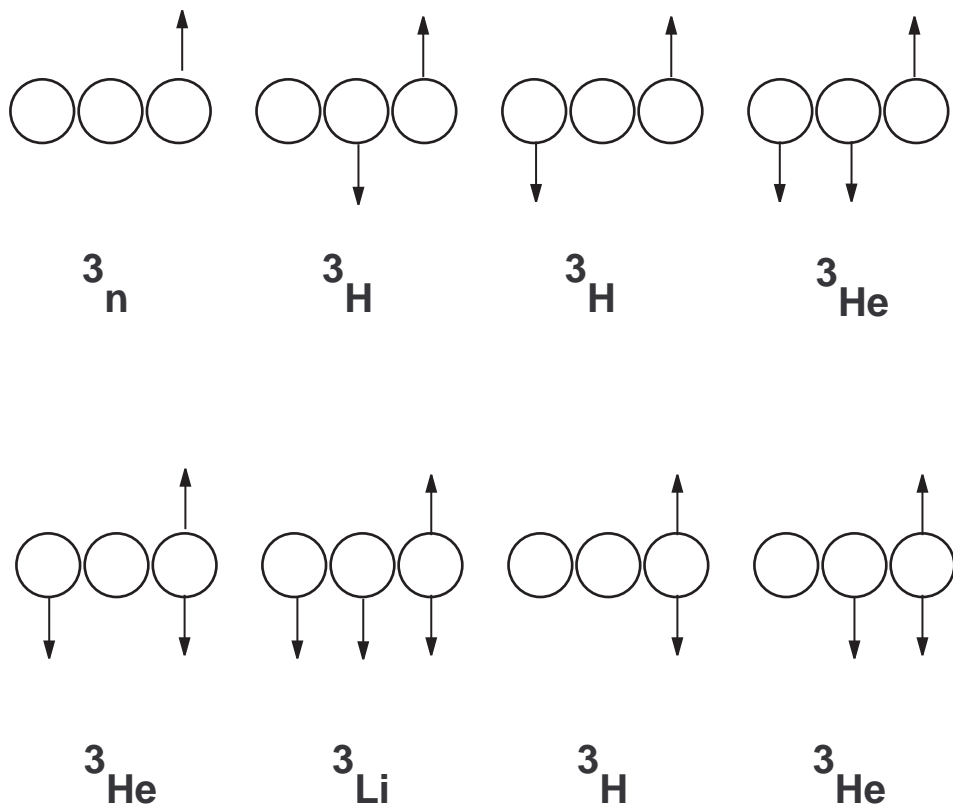


Figure 7: Triton in \mathcal{A}_μ^1 appearing as a mixture in \mathcal{A}_μ^2

kind (\mathcal{A}_μ^2) the collection is no longer chemically pure from the perspective of chemical reactions involving \bar{e}_2 and \mathcal{A}_μ^2 . It is then a mixture of isotopes of different chemical elements.

Thus, in Figure (7) the various isomers of 3H_1 (only six of these are distinct) will appear as 3n , 3H_1 , 3H_1 , 3He_2 , 3He_2 , 3Li_3 , 3H_1 , and 3He_2 .

We shall now present an outline of the method for determining the approximate masses of these isomers of nuclide (Z, A) in terms of the known masses of the nuclides (Z, A) given in the Tables of Isotopes [43]. In this calculation the masses of p, p', n, n' appear as parameters whose best values are determined by invoking the following hypothesis:

H_1 : The masses in the Tables of isotopes are those for isomers with lowest mass.

Consider a nucleus with atomic number Z and mass number A . Let us try to determine the mass of the nucleus in an isomeric state in which it has Z_1 protons (p) of mass $m(p)$ and Z_2 p-protons of mass $m(p')$, N_1 u-neutrons (n) of mass $m(n)$ and N_2 neutrons (n') of mass $m(n')$

The total mass of the system, for large atomic mass number A , may be approximated as

$$\begin{aligned}
M(Z, A; Z_1, N_1) = & Z_1 m(p) + (Z - Z_1) m(p') \\
& + N_1 m(n) + (A - Z - N_1) m(n') \\
& + \frac{1}{c^2} [\text{Nuclear binding energy} \\
& + \text{Coulomb repulsion energy} \\
& + \text{Kinetic Energies of Fermi gases}]
\end{aligned} \tag{35}$$

where

$$\begin{aligned}
\text{Nuclear binding energy} &= \frac{1}{2} n_b b A \\
\text{Coulomb repulsion energy} &= [Z(Z - 1) + \\
& (N_1 + Z_1)(N_1 + Z_1 - 1)] \frac{q^2 \xi}{2a} \\
\text{Kinetic energies} &= \frac{\lambda c^2}{a^2} (Z_1^{\frac{5}{3}} \frac{1}{m(p)} \\
& + (Z - Z_1)^{\frac{5}{3}} \frac{1}{m(p')} + N_1^{\frac{5}{3}} \frac{1}{m(n)} \\
& + (A - Z - N_1)^{\frac{5}{3}} \frac{1}{m(n')}) \\
\lambda &= \frac{3}{10} \left(\frac{9\pi}{4} \right)^{\frac{2}{3}} \frac{\hbar^2}{c^2}
\end{aligned}$$

n_b is the average number of nearest neighbors of a nucleon and $-b$ is the nuclear binding energy per nuclear bond (assumed to occur between pairs of nearest neighbors only). a is the radius of the spherical region over which the charges carried by the nucleons are confined. ξ is defined such that for a sphere of radius a the average value of $\frac{1}{r}$ between two points taken at random is $\frac{\xi}{a}$: $\xi = \frac{6}{5}$.

Since we are making the simplifying assumption that the binding energy $-b$ for $pp, pp', pn, pn', nn, np', nn', p'p', p'n', n'n'$ bonds are the same, we expect the experimental data on nuclear isotopes to exhibit an apparently random jitter around the masses derived in the model.

If it is assumed that a depends on A only then the minimum mass isomer has values for Z_1, N_1 given by the integers nearest in value to the solutions of the equations

$$\begin{aligned}
& m(p) - m(p') + (2Z_1 + 2N_1 - 1) \frac{g^2 \xi}{2a} + \\
& \quad \frac{5\lambda}{3a^2} (Z_1^{\frac{2}{3}} \frac{1}{m(p)} - (Z - Z_1)^{\frac{2}{3}} \frac{1}{m(p')}) = 0 \\
& m(n) - m(n') + (2Z_1 + 2N_1 - 1) \frac{g^2 \xi}{2a} + \\
& \quad \frac{5\lambda}{3a^2} (N_1^{\frac{2}{3}} \frac{1}{m(n)} - (A - Z - N_1)^{\frac{2}{3}} \frac{1}{m(n')}) = 0
\end{aligned} \tag{36}$$

Substitution of the values for Z_1, N_1 in (35) then gives the mass $M(A, Z)$ of the isomer with lowest mass.

The mass increments derived for the other isomers are thus found to be within the limits of experimental uncertainties in the tables of isotopes [43].

We now present an analysis of the two scenarios (X_1, X_2) mentioned in section (2.2)

Scenario X_1 : In this scenario we have $m(u_1) = m(u_2)$, $m(d_1) = m(d_2)$ and a constraint on f, g and the independent mass ratios among $m(e)$, $m(u)$, $m(d)$, $m(W)$ and $m(Z)$. This leads to $m(p) = m(n')$, $m(p') = m(n)$.

Two sub-scenarios (X_{11}, X_{12}) arise

X_{11} : The proton p is the observed stable proton. Then the u-neutron n must be the observed unstable neutron (which has mass different from that of the proton p). In this sub-scenario the p-proton p' (with mass equal to that of the u-neutron n) decays with a lifetime equal to that of the u-neutron n according to the following transitions.

$$\begin{aligned}
p' & \rightarrow p + \bar{e}_1 + \overline{\nu^{e2}} \\
p' & \rightarrow n' + \bar{e}_1 + \nu^{e1} \\
p' & \rightarrow p + \bar{e}_2 + \overline{\nu^{e1}} \\
p' & \rightarrow n' + \bar{e}_2 + \nu^{e2}
\end{aligned} \tag{37}$$

Notice that the first two decays mimic some aspects of the decay of an anti-neutron (in the standard model) Also in this scenario the u-neutron n decays according to

$$\begin{aligned}
n & \rightarrow p + e_1 + \overline{\nu^{e1}} \\
n & \rightarrow n' + e_1 + \nu^{e2} \\
n & \rightarrow p + e_2 + \overline{\nu^{e2}} \\
n & \rightarrow n' + e_2 + \nu^{e1}
\end{aligned} \tag{38}$$

In this scenario the observed part of the solar neutrino flux, being measured by experiments designed to look for a (binary) inverse of the first reaction in (38) only, is thus expected to be one fourth of the result derived from the standard model (plus the solar model [44]) if the modifications introduced by the present model into the solar model itself are ignored. This fact would seem to favor this scenario or the next one as most likely to have been realized in nature.

X_{12} : The p-proton p' is the observed stable proton. Then the neutron n' must be the observed unstable neutron which has mass different from that of p' . In this sub-scenario the proton p (with mass equal to that of the neutron n') decays with a lifetime equal to that of the neutron (n') according to the following transitions.

$$\begin{aligned}
p &\rightarrow p' + e_1 + \nu^{e_2} \\
p &\rightarrow n + \bar{e}_1 + \nu^{e_1} \\
p &\rightarrow p' + e_2 + \nu^{e_1} \\
p &\rightarrow n + \bar{e}_2 + \nu^{e_2}
\end{aligned} \tag{39}$$

Notice that the first two decays mimic some aspects of the decays of a neutron and an anti-neutron respectively (in the standard model). Also in this scenario the neutron n' decays according to

$$\begin{aligned}
n' &\rightarrow p' + e_1 + \overline{\nu^{e_1}} \\
n' &\rightarrow n + \bar{e}_2 + \overline{\nu^{e_1}} \\
n' &\rightarrow p' + e_2 + \overline{\nu^{e_2}} \\
n' &\rightarrow n + \bar{e}_1 + \overline{\nu^{e_2}}
\end{aligned} \tag{40}$$

In this scenario also the observed part of the solar neutrino flux, being measured by experiments designed to look for a (binary) inverse of the first reaction in (40) only, is thus expected to be one fourth of the result derived from the standard model (plus the solar model [44]) if the modifications introduced by the present model into the solar model itself are ignored. This fact would seem to favor this scenario or the previous one as most likely to have been realized.

Scenario X_2 : In this scenario we have $m(u_1) = m(d_2)$, $m(d_1) = m(u_2)$ and a constraint on f, g and the independent mass ratios among $m(e)$, $m(u)$, $m(d)$, $m(W)$ and $m(Z)$. This leads to $m(p) = m(p')$, $m(n) = m(n')$.

In this scenario the observed neutron is a mixture of n and n' and decays according to the transitions

$$\begin{aligned}
n &\rightarrow p + e_1 + \overline{\nu^{e_1}} \\
n &\rightarrow p + e_2 + \overline{\nu^{e_2}} \\
n' &\rightarrow p' + e_1 + \overline{\nu^{e_1}} \\
n' &\rightarrow p' + e_2 + \overline{\nu^{e_2}}
\end{aligned} \tag{41}$$

Notice that in this scenario each type of neutron has only two allowed kinematically equivalent decay channels. Contrasting this with the following four kinematically equivalent decay channels for the decay of μ_1 (which is the analogue of μ^- in the standard model)

$$\begin{aligned}
\mu_1 &\rightarrow e_1 + \nu^{\mu_1} + \overline{\nu^{e_1}} \\
\mu_1 &\rightarrow e_1 + \overline{\nu^{\mu_2}} + \nu^{e_2} \\
\mu_1 &\rightarrow e_2 + \nu^{\mu_1} + \overline{\nu^{e_2}} \\
\mu_1 &\rightarrow e_2 + \overline{\nu^{\mu_2}} + \nu^{e_1}
\end{aligned} \tag{42}$$

we see that the experimentally observed near equality of phenomenological Fermi coupling constants describing muon and beta decay [45] rules out this scenario in the present model with

$M_{W^1} = M_{W^2}$, $g_1 = g_2$. However this scenario may be resurrected if one goes beyond the present model and imposes the condition

$$\frac{g_2^2}{M_{W^2}^2} \ll \frac{g_1^2}{M_{W^1}^2}$$

where g_1, g_2 are the coupling constant associated with R_1, R_2 and M_{W^1}, M_{W^2} are the masses of the charged weak bosons.

Scenario X_3 : In this scenario it is postulated that

$$N_1 = 0 \quad , \quad Z_1 = 0 \tag{43}$$

for all nuclei in their ground states. Thus all nuclei in their ground state have $Q_2 = 0$ and they do not capture any \bar{e}_2 's in their vicinity. For such nuclei in their ground state there is one chemistry based on e_1 's and \mathcal{A}_μ^1 and the other chemistry based on e_2 's and \mathcal{A}_μ^2 can not occur. Since this condition (43) does not arise for the ground state in the heuristic model for nuclei based on hypothesis H_1 , proposed above, we can say that for this scenario to occur we may have either

Scenario X_{31} :

In this scenario the following hypothesis holds true.

H_2 : It is possible to include an additional term in the model for nuclei which has the desired effect of producing the condition (43) without producing results in violation of the empirical data on nuclear masses.

or,

Scenario X_{32} : In this scenario the following hypothesis is assumed to hold:

H_3 : It has been arranged by the inter-dependent web of life and environment in our vicinity (GAIA [46, 47]) that the nuclei with $N_1 = 0$ and $Z_1 = 0$ have been retained and all other nuclei excluded during the course of a few billion years of evolving life forms.

Scenario X_4 : This scenario envisages the possibility of the two parallel chemistries being identical and producing effects merely reinforcing each other and not causing matter to evolve along competing tracks of chemical evolution. It is suggested that the following paragraph be read immediately after the next section (6) when the reader would have become familiar with the notion of the four types of matter.

In this scenario, we envisage that the lowest mass isomers of nuclide A, Z are always such that Z_2 (the number of p-protons, p') is equal to N_1 (the number of u-neutrons n). This has the consequence that, in this scenario, the chemical identity of an atom of Type III matter with any nucleus (in its nuclear ground state) is the same in the two parallel chemistries - i.e. one chemistry that is based on e_1 and \mathcal{A}^1 and the other chemistry that is based on \bar{e}_2 and \mathcal{A}^2 . This is because the atomic number relevant to the first chemistry being $Z_1 + Z_2$ is equal in this scenario to the atomic number relevant to the second chemistry which is $Z_1 + N_1$. Thus in this

scenario the two observers depicted in figure (1) when looking at an atom of Type III matter, with its nucleus in the state of lowest energy, would see the same chemical object.

This scenario gives rise to sub-scenarios X_{41} and X_{42} analogously to X_{31} and X_{32} , according as hypotheses analogous to H_2 or H_3 hold.

6 Four Types of Matter and Anti-matter and Three Scenarios of Physical Theory

We have seen that in this model baryons and anti-baryons have $Q_1, Q_2 > 0$ and $Q_1, Q_2 < 0$ respectively. Four broad types of matter (anti-matter) are therefore possible.

Type I: Nuclei made of baryons (anti-baryons) enclosed in shells of e_1 s (\bar{e}_1 s) neutralizing the Q_1 charge on the nuclei while the Q_2 charge is not neutralized.

Type II: Nuclei made of baryons (anti-baryons) enclosed in shells of \bar{e}_2 s (e_2 s) neutralizing the Q_2 charge on the nuclei while the Q_1 charge is not neutralized.

Type III: Nuclei made of baryons (anti-baryons) enclosed in shells of \bar{e}_2 s (e_2 s) and e_1 s (\bar{e}_1) neutralizing both kinds of charges on the nuclei.

Type IV: Nuclei made of baryons (anti-baryons) with both kinds of charge active.

Thus in a bath of electromagnetic radiation of the first (second) kind [i.e., $\mathcal{A}_\mu^1(\mathcal{A}_\mu^2)$] matter of Type III would lose e_1 (e_2) and get converted into matter of the type II (I). Notice, also that nuclei of matter of the first type have a barrier against annihilation with nuclei of anti-matter of the second type. This is so because the *shells* of e_1 having $Q_1 < 0$ and $Q_2 = 0$ *surrounding nuclei* of matter of the first type do not directly interact with *shells* of e_2 having $Q_2 > 0$ and $Q_1 = 0$ *surrounding nuclei* of antimatter of the second type. So these shells are, respectively, exposed to direct interaction with the nuclei of anti-matter of the the second type and nuclei of matter of the first type (i.e. the non-corresponding nuclei). This direct interaction between the shells and non-corresponding nuclei is therefore repulsive and provides a barrier against mutual annihilation of the nuclei. However, so long as aggregates of the two different types of atoms are far apart, there is no long range (varying as $\frac{1}{r^2}$ or as $\frac{1}{r^3}$) force, except for gravitation, between them.

One might be inclined to think that the type III matter is the most common form of matter in our solar system since there are no strong long-range forces other than the weak force of gravity among the sun and the planets. Matter of Types I (II) would seem to be precluded from occurrence on large scale in the solar system since the strong repulsive force due to charge Q_1 (Q_2) carried by the two types of matter would necessitate the existence of an attractive force much stronger than the weak attractive force of gravity derived from the phenomenology of the solar system. On the other hand, we have to bear in mind the fact that this extremely weak force of gravity is believed to be a fundamental force of nature by the consensus of opinion prevalent at present.

So we can now argue that in order for this model to make empirical sense, in the context of the prevalent notion about the nature of weak gravity as a fundamental force, one of the following scenarios may hold

scenario S_1 : matter on earth and in the solar system is almost entirely of Type III . If this

is so then matter experienced by us is flooded with light of both kinds arising from atomic transitions involving both types of electrons. However as we have seen above a nuclide with a definite value of nuclear charge Q_1 (manifested when interacting with light \mathcal{A}_μ^1) may have one of several possible values of the nuclear charge Q_2 (manifested when interacting with light \mathcal{A}_μ^2).

So in the case of matter of Type III we would see the spectral lines due to the second kind of light produced in transitions of e_2 's among the energy levels of atoms with (several) corresponding chemical alternatives (Q_2 values) even if we were looking at materials of high chemical purity (definite Q_1 values) which we can easily prepare with the tools at our disposal. But this is clearly not observed to be the case.

Therefore we conclude that either of the following two sub-scenarios may occur.

sub-scenario S_{11} : matter accessible to us on earth, at least, is of Type I and not Type III. It might have been created from a primordial Type III state by a floodlight of the second kind which swept away most of the e_2 's (Some of the residual e_2 's left over since the primeval floodlight are manifested in the phenomena of superconductivity - see section (8.3), page (36). In this sub-scenario if, in agreement with the consensus, the role of the weak gravity as a fundamental force of nature is to be maintained then we can not allow the strong long range forces (due to the two kinds of charges) to operate and therefore apart from the earth (which is made of Type I matter) all the planets and the sun are composed of Type III matter. In other words, we have to give up the Copernican doctrine that the earth is not special in any fundamental way relative to the rest of the solar system.

sub-scenario S_{12} : matter accessible to us on earth is of Type III (as in the rest of the solar system). However we are not seeing the spectral lines due to the second kind of light because our consciousness is locked on to the chemical reactions in the retina involving e_1 's and \mathcal{A}_μ^1 and is oblivious to the chemical reactions in the retina involving \bar{e}_2 's and \mathcal{A}_μ^2 . This would explain the non- observation of the spectral line due to the second kind of light produced in transitions of \bar{e}_2 's in atoms of matter of Type III. Also notice that our photographic plates have been designed by us to be attuned to light of the first kind. Since the nuclides in the photographic plate with a definite value of Q_1 correspond to several different values of Q_2 we do not expect the Type III atoms associated with these nuclides to be also attuned to a chemical process triggered by light of the second kind. Thus our present day photographic plates are not constructed to be sensitive to light of the second kind and we would not see the imprint of the spectral lines due to light of the second kind on these plates.

Finally, we consider the scenario of rejecting the prevailing consensus about the nature of weak gravity as a fundamental force.

scenario S_2 : matter on earth, the planets and the sun is of the same Type (I), in conformity with the Copernican doctrine. There are strong repulsive forces between the sun, earth and planets due to the Q_2 charges carried by matter of Type I. These repulsive forces may be countered by almost equally strong gravitational forces, resulting in a net weak attractive force of classical gravity, in order to explain the phenomenology of the solar system. However, in order to realize this scheme in a natural fashion we can not have the residual weak gravity as a fundamental force. This is because the Q_2 charges carried by earth, the sun and the planets would depend on the temperatures of these bodies. The repulsive forces in the solar systems are therefore dependent on the temperatures. The strong attractive gravitational force, being a fundamental force, is independent of temperatures. The residual force of weak gravity is therefore dependent on the temperatures and is not a fundamental force. This scenario could

therefore be tested in an accurate version of the Cavendish experiment in which the gravitating bodies are maintained at different variable temperatures. Notice that in this scenario the fundamental force of gravity is almost as strong as electromagnetism of either kind and therefore one expects the problem of unification of gravity with all the forces to be simpler. Also, notice that in this scenario the residual force of weak gravity holding the sun and planets together would increase (decrease) with decreasing (increasing) temperature of the sun (since the charge Q_2 producing repulsive forces is expected to decrease (increase) with decreasing (increasing) temperature). This has the consequence of making the solar system a far more hospitable place for the evolution and continuation of life since there is a mechanism for regulating the temperature of planets in response to variations in solar brightness i.e. variation in the distance of the planets from the sun in response to changes in residual gravitation arising from changes in temperature.

At the same time this state of affairs obviates the logical necessity of space travel undertaken to get away from dying stars in search of other realms near younger stars. This finally leads to a resolution of the Fermi paradox [48] "If intelligent life can evolve so easily in the universe then where is the evidence of its visit to the earth?".

In view of the above discussion supporting the possibility for long term survival of life on earth having been well provided for by the Creator, the argument of Dyson [49] for realization of space travel: "There is nothing so big or so crazy that one out of million technological societies may not be driven to do so provided it is physically possible" becomes somewhat less compelling.

7 Answers suggested by the Model to the Questions

Returning to the questions posed in the first section we can now summarize the answers suggested by the model. There is no left right as-symmetry. The Lagrangian of the model has the bi-modal discrete symmetry introduced in section (3.4), page (20). However, the operation of parity transformations defined there is most likely not implementable by an operator in the (Hilbert) space of states. We are constrained to enlarge our notion of symmetry.

There is an almost unobservable universe with a preponderance of anti-matter having features completely symmetric to that of the presently known particles (leptons, quarks, light quanta, massive vector bosons) which interpenetrates our universe and yet does not produce mutual annihilation

Notice that matter of type I (type II) and anti-matter of type II (type I) can coexist the same regions of space without producing rapid mutual annihilation. This is because there is a barrier against the close approach of atomic nuclei of type I matter having $Q_1 > 0$, $Q_2 > 0$ and nuclei of type II anti-matter having $Q_1 < 0$, $Q_2 < 0$. This barrier is provided by the intervening shells of e_1 s (e_2 s) having $Q_1 < 0$, $Q_2 = 0$ ($Q_1 = 0$ $Q_2 > 0$) surrounding nuclei of type I matter (type II anti-matter) atoms. The shells of e_1 s and e_2 s, however, can have no direct influence on each other since they carry different types of charges which are coupled to different kinds of photons.

There are supernovas in the symmetric universe which are not observable directly. This is because there is another kind of light which fails to interact with the e_1 s of type I matter which are at the foundation of all observable chemical processes and the interdependent web of life and environment in our world [46, 47].

It is reasonable to hope for an understanding the apparent solar neutrino deficit [44] without invoking a mass for the neutrino for which there is no direct experimental evidence at present and which moreover introduces an element of arbitrariness one would prefer to avoid. The model provides us with enough flexibility to suggest [see, in particular, the discussion of scenarios X_{11} , X_{12} on page (27)] that this would happen when the following impediments to the application of the model to elementary particle physics data are removed.

a: Actual data from the various neutrino experiments are made freely available to all seeking access to it.

b: The mis-interpretation of the muon lifetime data for muon decay in optical fibres recently pointed out by Widom, Srivastava and Swain [50] is widely noticed and corrected. This has bearing on the values of the constants in the standard model.

What are the gamma ray bursts? Could they be novae or supernovae in the symmetric universe which look different to us because of the second kind of light? The present model suggests the following mechanism for gamma ray bursts, invisible dark matter in galactic halos and on intergalactic scales.

H_4 : There are regions with Type II matter and Type II anti-matter which intersperse regions with Type I matter and anti-matter.

Thus the distribution of total energy released in the gamma ray bursts and their frequencies of occurrence simply provide information on the size distribution of matter and antimatter fragments, their velocity and volume distributions in a flat non-expanding universe. The idea of a flat non-expanding universe in the context of a scalar theory of gravity has been studied as a viable alternative to problematic aspects of the standard model associated with gravitational singularities [8, 10].

Parenthetical remarks: [The scalar theory of gravity [10] in flat space has no singularities (unlike the Newtonian and Einsteinian theories) and reproduces the three standard results of Einstein's gravity [51], viz. the perihelion precession of mercury, deflection of light ray due to solar gravity and the Shapiro time delay [52] of radio signals grazing the sun. The Taylor-Hulse pulsar's behavior [53, 54] is enigmatic according to this theory of gravity, however.

It is important to realize that large scale distribution of galaxies have not shown any evidence for *variation in galactic numbers* inside cosmic spherical regions centered around us *with the radii* of those regions. Such variations, had they been noticed, could have been interpreted, through the Cosmological Principle, as evidence for curvature in three dimensions. The large scale flatness of space is now a generally accepted, but not explicitly acknowledged, fact about the cosmos [55], [56], [57]. Also, it is instructive to recall that according to the idealist Kant [58], who was the first to give us the picture of the milky way as an island universe of stars being viewed from a location near its periphery, flat three dimensional space is an *a priori* mental category for human thought processes. Indeed, without such a starting point, Kant could not have reasonably suggested the picture of the galaxy that is now such an integral part of the universally accepted world view! The mathematical notion of space, of course, does allow curved spaces, since Euclid's axiom of parallels and its negation are both compatible with all the other axioms. But the question not addressed so far in this context is the following. Is there another axiom apart from the axiom of parallels which has been overlooked in the set of axioms adopted to simulate the mathematical model of physical space? There are hints suggesting

that there is such an overlooked axiom which has the consequence that the negation of Euclid's parallel postulate in three dimensions is no longer compatible with the other axioms and that the duality aspects of quantum mechanics do not seem compatible with the present model of space because of this oversight.]

Finally, we need to briefly mention the possibility that some of the gamma ray bursts could be due to the nuclei of type II anti-matter atoms getting annihilated in the earth's atmosphere. If so, then mobilization of a world-wide endeavor for harvesting these atoms as a clean source of energy is an obvious suggestion. These atoms of type II anti-matter could also be producing a mis-interpreted signal in the underground detectors. The effects of the intervening shells of e_1 s and e_2 s on the non-corresponding nuclei captured by them needs to be calculated before definite predictions of characteristics of the signals can be made. This has not been completed yet.

What is the nature of CBR?

Proposed answer: It is due to the second kind of light interacting with the baryons and anti-baryons of the dark matter in our vicinity producing a gentle shaking up of the barons and anti-baryons acting as transmitters of our kind of light.

The CBR is not due to a primordial initial singularity which, as mentioned earlier, is not needed to explain the cosmological redshift. The microwave background is due to the gentle shake up of atomic nuclei which are immersed in the ambient light of the second kind emanating from the (locally dominant) interpenetrating fragment of cosmos of type II matter and anti-matter in our vicinity. See also the discussion of the Great Attractor problem in section (8.2), page (35) which corroborates this viewpoint and explains the near equality of magnitudes and opposite directions for velocities of the sources of CBR (predominantly of type II matter and antimatter) and of the local distribution of (type I) matter.

8 Proposed Experiments and Related Topics

8.1 Storage Ring Experiment

Let us assume first that matter on earth and the solar system is of type III. We could then try to confirm this by doing the experiment described below. We could take protons and nuclei out of atoms in such a way that not only e_1 s but also \bar{e}_2 s are shaken out of the atoms. At present, we are making protons and nuclei using our electromagnetic technology, which is based on e_1 s and the first kind of light. Our consciousness is locked into the collective behavior of the e_1 's in our bodies. So this will not help us get rid of the \bar{e}_2 's clinging on to the protons and nuclei made in various devices based on electromagnetism associated with e_1 s and the first kind of light—devices which are manipulated by hands and eyes locked into consciousness (or subjective attention) attuned to e_1 s and the first kind of light. Although our devices and bodies and everything on earth, sun and stars are flooded with \bar{e}_2 s clinging to the nuclei (if they are made of type III matter), we have been unable to detect these so far - but only until now, since it is possible to detect them by initiating the following sequence of manipulations using our existing capabilities.

We take the nuclei and using existing technology, strip them of e_1 s first, and then accelerate them with the the same technology for storage in rings containing these nuclei moving in

counter-rotating directions. This is the first stage. In the second stage, the nuclei moving in opposite directions are arranged to collide with each other, so that the second kind of electromagnetism between \bar{e}_2 s and nuclei is brought into play. Recall that \bar{e}_2 ’s have Q_2 charge of -1 and nuclei have $Q_2 > 0$. This would remove the clinging \bar{e}_2 and keep the nuclei intact—provided the collisions are arranged to be not too violent.

Now these nuclei, which have been completely or partially stripped of \bar{e}_2 s could be stored in one of the rings containing these protons/nuclei. It can be arranged that they maintain constant speed by providing electrical energy from our present devices (i.e. the microwave cavities around storage rings of our present day accelerators). Nuclei are being accelerated and produce electromagnetic radiation of both kinds since $Q_1 > 0$ $Q_2 > 0$ for these the nuclei. We can now measure the rate of energy transfer to the nuclei to compensate for the energy loss due to radiation from accelerated nuclei through emission of photons of both kinds. This rate of energy input into nuclei to maintain their constant speed can presumably be measured easily by reading the power meters provided by the engineers. Thus for nuclei this rate of energy consumption in the storage ring would be expected to be more than what it would be if $Q_2 = 0$ by a factor $\frac{Q_1^2 + Q_2^2}{Q_1^2}$.

If matter on earth is of type I then we need only strip the nuclei of e_1 s using our electromagnetic technology. There are no \bar{e}_2 s attached to the nuclei and we can skip the second stage and proceed directly to the last stage in the experiment outlined above.

8.2 Great Attractor

As a preliminary to a description of the second experiment, we give the following quotation from Peebles [59] which describes the so called ‘Great Attractor’ in astrophysics and describe an alternative proposed explanation for it.

“The motion of the Solar system relative to the frame in which CBR is isotropic is $v_{\odot} - v_{CBR} = 370 \pm 10$ km/s, to $\alpha = 11.2$ h, $\delta = -7^\circ$, $\ell = 264.7 \pm 0.8^\circ$, $b = 48.2 \pm 0.5^\circ$. The conventional correction for the solar motion relative to the Local Group is 300 km/s to $\ell = 90^\circ$, $b = 0$. This is close to the mean motion defined by the Local Group and to the velocity that minimizes the scatter in the local distance-redshift relation. With this correction the velocity of the Local Group relative to CBR is 600 km/s toward $\alpha = 10.5$ h, $\delta = -26^\circ$, ($\ell = 268^\circ$, $b = 27^\circ$). This velocity is much larger than the scatter in local redshift-distance relation”

We need not invoke a fictitious Great Attractor to explain why the motion of the source generating CBR is with a velocity equal in magnitude and opposite in direction to that of the matter in the local group. Besides, the Great Attractor hypothesis has no explanation for the equality of the two velocity magnitudes. A more plausible explanation is as follows.

There is a vast region of dark matter atoms (assumed to be composed of either \bar{e}_2 and baryons or e_2 and anti-baryons, i.e. type II matter or anti-matter) in juxtaposition with ordinary matter atoms (assumed to be of type I matter and composed of e_1 and baryons) constituting the visible objects of the Local Group. The ordinary matter is partaking of the overall (large scale) motion of dark matter moving around it. If it is now assumed that the situation is analogous to that in which it seems “as if” (*) the sense of time flow is reversed for dark matter relative to

ordinary matter (type *I*) then it would appear to be moving in a direction opposite to that of the surrounding ordinary matter with a velocity equal in magnitude to that of the ordinary matter. In this picture the source of CBR would then be the dominant dark matter component of our cosmic neighborhood. More explicitly, the CBR effect observed is due to the interaction of second kind of light (\mathcal{A}_μ^2) produced by dark matter atoms with the baryons ($Q_1 > 0, Q_2 > 0$) or antibaryons ($Q_1 < 0, Q_2 < 0$) in the predominantly type II matter or anti-matter in our cosmic neighborhood.

(*) An explanation of what is really meant by the above statement "analogous to that in which it seems "as if" the sense of time flow is reversed .." will now be given. Let us first emphasize that nothing mysterious is being suggested by this statement. All that is being said is that in statistical mechanical systems, under appropriate boundary conditions, it may happen that the motion of a sub-system acquires characteristics that one might usually associate with the backward evolution in time of the system. Thus for example, in most laboratory situations waves propagate outwards from a point. However, one can easily subject matter to unusual boundary conditions in which its behavior has the appearance produced by a cylindrical wave propagating from the boundary of the cylindrical container to its axis. The reader might try observing water in a pot placed on an old washing machine which vibrates with a large amplitude when it is run.

8.3 Superconductivity Experiment

In preparation for the description of our second experiment, we next ask

Question: Are the Cooper pairs in superconductor really consisting of two electrons with oppositely directed velocities of equal magnitude?

Proposed Answer: No. They are composed of e_1 and \bar{e}_2 (present in matter of type III or possibly type I at low temperatures) undergoing a similar overall motion inside a superconductor. The reason their velocities seem oppositely directed is because the \bar{e}_2 's are moving with a sense of time flow reversed relative to the e_1 's (analogous to the phenomena associated with the Great Attractor described above). Thus the interaction between the pairs (e_1, \bar{e}_2), locked in oppositely directed motions, occurs here also through the intermediacy of nuclei, just as it does in the BCS theory of superconductivity [60]. However the actual mechanism is different. It is not that of phonons associated with nuclei. Rather it is due to both kinds of charges carried by the nuclei.

Notice that this proposed mechanism can explain in a very natural fashion the experimentally observed separation of regions of charge and spin localisation in high temperature superconductors [61, 62, 63] subjected to neutron diffraction analysis. There is no great difficulty in comprehending this phenomena within the framework of a two component model involving e_1 's and \bar{e}_2 's, in contrast to the usual models based on e_1 's only which seem too artificial.

We now describe the following experiment that may be set up to test for this proposed answer which is suggested by the model of elementary particle interactions presented in this paper.

We take a long superconductor. We stir up e_1 's at one end of it using electromagnetic fields associated with light of the first kind. When e_1 's are accelerated by the applied electromagnetic fields they produce an overall motion of \bar{e}_2 , occurring through the intermediacy of nuclei with both kinds of charges. The accelerated \bar{e}_2 are then expected to emit light of the second kind, which can be reflected by a mirror made of a good reflector for \mathcal{A}_μ^2 to a remote replica

of the superconductor. Notice that a chemically homogeneous nuclide for \mathcal{A}_μ^1 is not necessarily chemically homogeneous for \mathcal{A}_μ^2 [as explained in section (5), page (23)] and the search for a good mirror for \mathcal{A}_μ^2 would involve a bit of trial and error. Once this has been successfully achieved one expects to see flashes of ordinary light (\mathcal{A}_μ^1) from the remote superconductor as the shaking up of e_2 's by the incident \mathcal{A}_μ^2 induces motion of e_1 's through the intermediacy of nuclei carrying both kinds of charge.

9 Non-coding Segments of the DNA

If matter on earth and the solar system is of type III (including living matter on earth) then, as explained above, the usual electromagnetic fields are being generated with devices assembled by us with eyes sensitive to \mathcal{A}_μ^1 , because our consciousness must have been locked to chemical processes in the retina produced by e_1 's interacting with \mathcal{A}_μ^1 . Chemical processes produced by \bar{e}_2 's interacting with \mathcal{A}_μ^2 are also present (in matter of type III and presumably also in matter of type I at low temperatures). However the effect of the latter chemical processes on consciousness would be indirect (i.e. through the intermediacy of interactions of \mathcal{A}_μ^2 with nuclei carrying both kinds of charge). Thus it is understood that although the chemical processes involving e_1 's and \bar{e}_2 's may be similar in intensity and frequency of occurrence, the effects on consciousness may be quite different in their vividness. Since the chemical processes involving \bar{e}_2 and \mathcal{A}_μ^2 influence consciousness indirectly unlike the direct effect on consciousness of processes involving e_1 's and \mathcal{A}_μ^1 , the question of a possible mechanism for this is now raised. It is suggested that this could have been arranged by Nature through a segregation of the segments of DNA specialized in exercising chemical control via one or the other of the two parallel chemical mechanisms. If this is so then it would explain why some segments of the DNA [64] can not be analyzed by the usual methods of chemical analysis (attuned to human consciousness) to determine their function and they would appear to be non-coding and dormant.

Finally, let us emphasize that the nature of physical reality may well be more complex than a simple once and for all selection between the various scenarios. Thus, for example, non-living matter in the solar system (except the earth) may be type I. However living matter on earth may be type III.

10 Charged Neutrino

The model has one neutrino with $Q_1 = 1$ and $Q_2 = 1$ associated with each family. Have these neutrinos been seen? We propose that the jets of hadrons produced in e_1, \bar{e}_1 collisions are not due to constituent quarks since the masses of the hypothetical quarks turn out to be quite small compared to the hadron masses. If quarks really have the low masses suggested by the jet phenomenology and they are almost non-interacting at short range [65] then the large masses of hadrons (presumed to be lowest energy states of quark systems) are quite problematic. We believe that we can not avoid this paradox by introducing the hypothetical mechanism of quark confinement which has not received explicit demonstration so far. The so called mass gap [66]

problem in which mathematical physicists have been interested (and whose precise formulation is as of now not available), is most likely a reformulation of this paradox.

So if the jets can not be due to quarks then they may be something else. The most natural candidates suggested by this model are the charged neutrinos. In fact we believe that the study of jets may be used to understand the quantum field theory of massless charged particles. [67, 68]

11 Criticism of the Model and Conclusion

In conformity with the prevalent ideas we still have only the weak requirement of "renormalizability" [32, 33, 34, 35] for the model. However in agreement with Dirac's views [69], we believe that renormalization in a fundamental theory is to be regarded as a calculable and physically measurable departure from a conceptually simpler situation - in other words renormalization effects must all be finite. In the present model, although some of the infinities arising in renormalization integrals (other than those associated with the anomalous Feynman diagrams [38, 40, 39]) do cancel, other infinities survive. We believe that the model must eventually evolve to the stage in which all divergences of Feynman diagrams cancel (not just those of the anomalous diagrams). This may be possible, since the model provides hints of new kinds of symmetries linking scalars, fermions, and vector bosons (these symmetries are implemented differently from supersymmetry [70]).

Dirac's dream of a finite quantum field theory is closer to realization.

Failure to realize this dream has led some of us to propose the radical viewpoint that there are various levels of descriptions with their own laws. However we feel that if the non existence of a calculable mechanism to derive laws at any stage from those at a more fundamental level is accepted as a matter of principle, then what we are really saying is that there is no physical theory and that it is just an exercise in very complicated parameter fitting of experimental data.

12 Appendix

Representation for the Dirac γ -matrices are taken to be

$$\begin{aligned}\gamma^0 &= \begin{pmatrix} 0 & I \\ I & 0 \end{pmatrix} \quad \gamma^i = \begin{pmatrix} 0 & \sigma^i \\ -\sigma^i & 0 \end{pmatrix} \\ \gamma_5 &= i\gamma^0\gamma^1\gamma^2\gamma^3 = \begin{pmatrix} -I & 0 \\ 0 & I \end{pmatrix}\end{aligned}\tag{44}$$

so that

$$\gamma^{0\dagger} = \gamma^0, \quad \gamma^{i\dagger} = -\gamma^i\tag{45}$$

$$\gamma^{02} = -\gamma^{i2} = \begin{pmatrix} I & 0 \\ 0 & I \end{pmatrix} = \mathcal{I}\tag{46}$$

In this representation the matrix C defined by

$$C\gamma^{\mu*}C^{-1} = -\gamma^{\mu}$$

and

$$C^\dagger = -C$$

is given by $C = \pm\gamma^2$.

$$\text{Thus } C^* = -C, \quad C^2 = -\mathcal{I}, \quad C^t = C$$

[$*$ is complex conjugation, t is transposition and \dagger is hermitian conjugation of a matrix]

This matrix C has the property that if q transforms under Lorentz transformations as a Dirac spinor then Cq^* also transforms as a Dirac spinor.

The left handed component of q is defined as

$$q_L = \frac{1}{2}(1 + \gamma_5)q$$

The right handed component of q is defined as

$$q_R = \frac{1}{2}(1 - \gamma_5)q$$

We define q'_R, q'_L as

$$q'_R = Cq_L^*, \quad q'_L = Cq_R^*$$

Then

$$q_L = Cq'_R^*, \quad q_R = Cq'_L^*$$

The matrix C defined above also satisfies the relation

$$C\gamma^0\gamma^\mu C^{-1} = (\gamma^0\gamma^\mu)^t$$

The above relations imply (for anti-commuting spinors q, r) that

$$\begin{aligned}
\bar{q}_R \gamma^\mu r'_R &= -\bar{r}_L \gamma^\mu q'_L \\
\bar{q}'_R \gamma^\mu r'_R &= -r_L \gamma^\mu q_L \\
\bar{q}_R \gamma^\mu r_L &= \bar{q}'_R \gamma^\mu r'_L = 0 \\
\bar{q}_R \gamma^\mu r'_L &= \bar{q}'_R \gamma^\mu r_L = 0
\end{aligned} \tag{47}$$

The actions of generators of R_1 and R_2 on the multiplet $(q_h, r_h, q'_{\bar{h}}, r'_{\bar{h}}, s'_{\bar{h}}, t'_{\bar{h}}, s_h, t_h)$ are deducible from (16).

For the generators $T^i(S^i)$ of $R_1(R_2)$ the actions on the multiplet, expressed as a column vector, are given by multiplication of the column vector on its left with the matrices $F^i(G^i)$ which are as follows: [We have set the values of the parameters $\xi_1, \xi_2, \eta_1, \eta_2$ to +1, which have turned out to be the only values of relevance at this stage]

$$F^i = \frac{1}{2} \begin{pmatrix} \sigma^i & 0 & 0 & 0 \\ 0 & -\sigma^{i*} & 0 & 0 \\ 0 & 0 & \sigma^i & 0 \\ 0 & 0 & 0 & -\sigma^{i*} \end{pmatrix} \tag{48}$$

$$\begin{aligned}
G^3 &= \frac{1}{2} \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & -I & 0 & 0 \\ 0 & 0 & I & 0 \\ 0 & 0 & 0 & -I \end{pmatrix} \\
G^1 &= \frac{1}{2} \begin{pmatrix} 0 & 0 & 0 & \sigma^2 \\ 0 & 0 & \sigma^2 & 0 \\ 0 & \sigma^2 & 0 & 0 \\ \sigma^2 & 0 & 0 & 0 \end{pmatrix} \\
G^2 &= \frac{-i}{2} \begin{pmatrix} 0 & 0 & 0 & \sigma^2 \\ 0 & 0 & -\sigma^2 & 0 \\ 0 & \sigma^2 & 0 & 0 \\ -\sigma^2 & 0 & 0 & 0 \end{pmatrix}
\end{aligned} \tag{49}$$

Using the relation $\sigma^2 \sigma^{i*} = -\sigma^i \sigma^2$

one may verify that these matrices satisfy the commutation relations

$$\begin{aligned}
[F^i, F^j] &= i\epsilon^{ijk} F^k \\
[G^i, G^j] &= i\epsilon^{ijk} G^k \\
[F^i, G^j] &= 0
\end{aligned} \tag{50}$$

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